Industrial Hygiene and Occupational Health
This book is a part of the course by Jaipur National University, Jaipur.
This book contains the course content for Industrial Hygiene and Occupational Health.

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### Abbreviations

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<th>Description</th>
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<td>BWAs</td>
<td>Biological Warfare Agents</td>
</tr>
<tr>
<td>CBD</td>
<td>Chronic Beryllium Disease</td>
</tr>
<tr>
<td>CWAs</td>
<td>Chemical Warfare Agents</td>
</tr>
<tr>
<td>GEMS</td>
<td>Global Environmental Monitoring System</td>
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<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>MVV</td>
<td>Maximal Voluntary Ventilation</td>
</tr>
<tr>
<td>PPE</td>
<td>Personal Protective Equipment</td>
</tr>
<tr>
<td>ULV</td>
<td>Ultra Low Volume</td>
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Chapter I
Occupational Health and Physical Health Hazards

Aim
The aim of this chapter is to:

• explain occupational health and hygiene
• define occupational health hazards
• define physical health hazards at workplace

Objectives
The objectives of this chapter are to:

• define occupational health hazards and their control
• explain the types of physical health hazards
• explain problems caused by physical health hazards

Learning outcome
At the end of this chapter, you will be able to:

• understand ways to control occupational health hazards
• identify occupational health program
• define layout and house keeping
1.1 Introduction

Occupational health and safety is a discipline with a broad scope involving many specialised fields. In other words, occupational health and safety encompasses the social, mental and physical well-being of workers that is the “whole person”. Successful occupational health and safety practice requires the collaboration and participation of both employers and workers in health and safety programs, and involves the consideration of issues relating to occupational medicine, industrial hygiene, toxicology, education, engineering safety, ergonomics, psychology, etc.

Occupational health issues are often given less attention than occupational safety issues because the former are generally more difficult to confront. However, when health is addressed, so is safety, because a healthy workplace is by definition also a safe work place. Nowadays people in the management realise that health of the workers is an important factor, hence they see to it that they employ healthy workers, by subjecting the selected worker to pre-employment medical examination and they are taken on job only if they are medically fit. Hence, it is the duty of the management to see to it that the fit worker does not suffer from any illness on account of his work. Health of the worker is influenced by:

- Occupational factors (working environment)
- Non-occupational factors (food, clothing, water, housing, diet, and personal habits like smoking, alcohol consumption etc.)

The interaction of the worker with his working environment may result in impairment of his health leading to work related illness also known as occupational diseases.

Major concerns related to safety and worker’s health:

In its broadest sense, safety should aim at:

- the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations;
- the prevention among workers of adverse effects on health caused by their working conditions;
- the protection of workers in their employment from risks resulting from factors adverse to health;
- the placing and maintenance of workers in an occupational environment adapted to physical and mental needs;
- the adaptation of work to humans

It is stated that if a worker has to give his maximum, following are the three important factors:

- Economic satisfaction of earning a livelihood
- Social satisfaction of identifying himself as one in the group
- Individual satisfaction of doing a job well

1.2 Occupational Health and Occupational Disease

The WHO defines Health as a state of physical, mental, social and spiritual well being and not just an absence of disease and/or infirmity. Occupational Health is a specialised branch of preventive medicine, which deals with not only prevention of occupational disease but also enhancement of the present state of health of workers in order to increase work-efficiency and productivity.

![Work Environment Diagram](image)

**Fig. 1.1 Relationship between occupation and health**
Occupational diseases are those which may arise out of or in the course of employment. The working environment has got direct effects on the health of persons who are present in the area. The environment may be responsible in the causation and/or exacerbation of other non-occupational diseases. The state of health of the worker can influence his ability to work safely and efficiently. The presence of contaminants in the air, physical factors like heat, humidity, radiation etc. have got effects on the state of health of workers. It is therefore of vital importance that the employees who are required to work in industries are protected and kept in a healthy state.

### 1.3 Occupational Health Hazards in Work Place
Occupational health hazards are classified as:

<table>
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<tr>
<th>Physical health hazards</th>
<th>Noise, heat, cold, vibration, radiation, atmospheric pressure, etc</th>
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<tr>
<td>Chemical health hazards</td>
<td>Exposures to chemicals like metals, gases, pesticides, solvents etc.</td>
</tr>
<tr>
<td>Biological health hazards</td>
<td>Snake bites, anthrax, Hay fever, HIV, Hepatitis B and other infections</td>
</tr>
<tr>
<td>Psychosocial health hazards</td>
<td>Occupational stress, job satisfaction, absenteeism, addictions, VRS, Debt, etc.</td>
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**Table 1.1 Classification of occupational health hazards**

### 1.4 Occupational Health Hazards and their Control
The control measures can be at three different points, i.e.,
- Source
- Air path (work environment)
- Receiver

| Source                          | • Substitution e.g. Toluene for benzene, Tri-chloro-ethylene for carbon, Tetrachloride, Silicon Carbide for Silica in grinding stone  
|                                | • Change of process  
|                                | • Enclosure of process(Isolation)  
|                                | • Capturing at source e.g. local exhaust ventilation, wet methods  
|                                | • Adequate and Regular Maintenance of Machines  
| Air path (work environment)    | • Good House Keeping (Work Environment)  
|                                | • General Exhaust Ventilation (Fans)  
|                                | • Dilution Ventilation  
|                                | • Increasing distance between source and Receiver e.g. Remote control, Semi-automatic operations  
|                                | • Continuous area monitoring with preset alarms.  
|                                | • Environmental monitoring (TLV)  
| Receiver                       | • Training and education with regular update  
|                                | • Rotation of workers  
|                                | • Enclosure of workers (Air-conditioning, Isolation)  
|                                | • Personal monitoring devices like dosimeters, pocket Electro chemical sensors etc.  
|                                | • Personal protective equipment  
|                                | • Adequate maintenance programs(occupational health program)  

**Table 1.2 Control of occupational health hazards**
1.5 Occupational Health Program

Following are the occupational health programs:

Pre-Employment medical examination
A worker, before he is employed and placed in a particular job should undergo a thorough medical examination, along with necessary special investigations, and the records of such examinations are maintained properly. During this examination the doctor should have the full details of the job description including flexibility. So that the medical exam could be a job oriented one in which the target or critical organ involved could be specifically evaluated and documented to provide a baseline data and any susceptibility recorded. For example, a liver profile should be included for people working in organic solvents or history of asthma in case of exposure to fumes or dusty operations.

Advantages:
- Know individual susceptibility to a particular occupational disease.
- Procure a baseline data for future comparison.
- Have record in case of compensable and/or noticeable diseases.

The aim of pre-employment medical examination is not to declare any one fit or unfit but to select the right person for the right job.

Periodic health examination
Whether the working environment is congenial to health or otherwise can be known with the determination of the state of health of the employees working therein. However, working environment is not of much relevance as compared to the personal susceptibility, individual habits and general physical fitness of the worker. The effect of working environment on health will vary from worker to worker performing similar type of work. Therefore, it is necessary that each worker needs to be medically monitored for assessing the state of his health. After his being employed in the industry, it is necessary that he should be reexamined periodically every year, to detect any departure from his normal state of health. Such routine health examinations are statutory for workers. The periodic health examination would include the critical organ evaluation to prevent increasing body burdens to the work environment.

The periodic medical health examination should include the following:
- **Complete physical examination and history** taking note of early development of any occupational disease with a regular follow-up. A detailed medical history, history of smoking, tobacco, and alcohol should also be recorded.
- **Pathology tests:** This test should be tailored to evaluate the target organ e.g. Haemogram in lead industries, liver profile for organic solvents, kidney profile and urine for aniline dyes, sputum for asbestos etc.
- **ECG** is usually advisable for all workers above 40 years of age.
- **Lung Function Tests:** These tests are advisable for dusty operations and also where workers are exposed to chemical fumes.
- **X-Ray:** It is now a popular concept among occupational health physicians to advise an X-Ray only in clinically suspect cases or once in three years for routine screening.
- **Specific hazard related tests (biological monitoring):** These tests are useful indicators for exposure to specific chemicals. For example
  - Determination of blood and urinary lead levels
  - Determination of Phenol in urine to know exposure to Benzene
  - Determination of Cholinesterase levels in blood to know exposure to Organo Phosphorus pesticides.
- **Statutory provisions for Medical Examination under the Factories Act.**
  - Examinations should be conducted quarterly, half yearly, and yearly as required.
  - Records of periodic medical examination of each worker should be maintained.
Certificate of fitness of each worker duly endorsed by the Certifying Surgeon in Health Register Form 7 should be procured for workers in Hazardous processes (Schedule I) (Section 41-B, 41-C & 112, Rule 73-V (3), (4), (5)). In addition, a special Certificate of Fitness in Form 32 should also be procuring for workers in Dangerous Operations (Section 87C, rule 114) and in Form 23 for workers in Dangerous Operations (Schedule III, VI, VIII, XI, and XXII).

Setting up of Occupational Health Centre (Section 41-B, 41-C, 112, 73-W).

Pre placement medical examination
Pre-placement medical examination is conducted on those people who are already employees of the company. It is required if a worker needs to be transferred from one job profile to another or in cases of chronic absenteeism.

Pre and post retirement medical examination
The onus of responsibility is on the management to ensure that the employee leads a healthy retired life. Medical examination should be conducted for the diseases like Asbestosis, cancer, bysinossis.

Health audit
Occupational health audit completes the total commitment towards health and safety of an organisation in line with international standards. Occupational health audit should have the following minimum components based on known occupational hazards and existing legislation:

• Identification of occupational hazards.
• Collection and development of information/database regarding various factors of occupational hazards.
• Evaluation of work environment along with personal and static monitoring.
• Feasibility study for control measures.
• Pre-employment and periodical medical examination of workers in relation to occupational health hazards to which they were exposed or will be exposed.
• Maintenance of health records.
• Rehabilitation and social justice.
• Compliance to the existing legislation regarding occupational health in particular.
• Development of an attitude for accepting future probable development on the subject.

1.6 Emergency Medical Response in Disaster Management
The medical responses in emergencies has to be well planned and organised so that in case of major emergencies victims can be managed medically in the best possible manner and without any delay.

The medical emergency response should not be limited to rendering of first-aid and transporting the victims to the hospital but should extend to hospital admission, hospital stay, hospital procedures, discharge and rehabilitation.

First-aid training
An adequate number of workers who are trained and certified in First-aid should be present per shift. We advocate 10 in big units and 6 in small. There is a provision for this in the factories act. (Ch.V, Rule 45) (Section 41-B, 41-C, 112, 73-W).

Training in occupational health and safety
Periodic training programmes with regular updates and should be conducted to implement the concept of occupational health safety. Regular mock drills should also be conducted to see the in-house preparedness for emergency.
Advantages of occupational health program
- Improvement in working capacity of the most important resource, i.e. The Human Resource
- Increase in productivity
- Increase in profits by decrease in lost working hours
- Decrease in sickness absenteeism
- Improved industrial relations
- Saving on expenses of medical bills
- Fulfillment of the statutory requirements under the provisions of the Factories Act.

Occupational Health Provisions in the Factories Act
- Pre-employment Medical Examination and Certificate of Fitness
- Periodic Health Examination (quarterly, half-yearly, yearly)

1.7 Physical Health Hazards

The nature of physical agents is wide and should not be underrated but the main ones capable of causing occupational disorders or injuries are given below.

Different Types of Physical Health Hazards
Various types of physical health hazards are listed in the table below:

Physical factors

<table>
<thead>
<tr>
<th>Physical factors</th>
<th>Hazard descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Heat, cold, changing temperature,</td>
</tr>
<tr>
<td>Noise</td>
<td>Continuous impact, intermittent</td>
</tr>
<tr>
<td>Vibration</td>
<td>Ultrasound, generalised and localised</td>
</tr>
<tr>
<td>Defective illumination</td>
<td>Glare, dark</td>
</tr>
<tr>
<td>Colour scheme</td>
<td></td>
</tr>
<tr>
<td>Ionising radiation</td>
<td>Alpha particles, Beta Rays, Gamma Rays, X-Rays, Neutrons</td>
</tr>
<tr>
<td>Non ionising radiation</td>
<td>UV Radiation, infrared radiation, microwave radiation, laser beams</td>
</tr>
<tr>
<td>Atmospheric pressure</td>
<td>High and low</td>
</tr>
<tr>
<td>Lay out and house keeping</td>
<td></td>
</tr>
</tbody>
</table>

Table 1.3 Different types of physical health hazards

1.7.1 Temperature
The human body has a very sensitive temperature control mechanism. Skin temperature may vary but the deep body temperature remains constant at 37°C. Heat is generated through out the life by the process of metabolism but the phenomenon of heat balance, heat exchange and heat loss keeps it maintained without any adverse effects. Heat and cold represent opposite extremes of body temperature and occupational hazards are encountered in both the situations.

1.7.2 Heat
In industries where conditions with high heat exists – radiant convicted – the air becomes warm and sweating becomes necessary for body to loose heat. In some industries processes are with high heat and humidity – textile – where the condition becomes worse. Human sweat contains a substantial amount of salt and its deficit may cause ill effects. Failure of body to adjust the heat stress produces disorders by
- Depletion of salt due to produce sweating and
- Rise in body temperature due to the failure of the normal thermo-regulatory mechanism.

Following are the health disorders caused by excessive heat:

<table>
<thead>
<tr>
<th>Systemic</th>
<th>Skin</th>
<th>Psychoneurotic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat stroke</td>
<td>Prickly heat</td>
<td>Heat fatigue</td>
</tr>
<tr>
<td>Heat exhaustion</td>
<td>Milliaria rabra</td>
<td>Loss of emotional control</td>
</tr>
<tr>
<td>Heat syncope</td>
<td>Cancer</td>
<td></td>
</tr>
<tr>
<td>Heat cramp</td>
<td>Rodent Ulcer</td>
<td></td>
</tr>
<tr>
<td>Dehydration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1.4 Health disorders caused by excessive heat

Prevention and control
- Adequate intake of food and salt
- Proper protective clothing (light, thin, cotton and loose fitting)
- Safe exposure time adjustment
- Engineering control of environment heat
- Medical control
- Acclimatisation of the worker (stepwise exposure to high temperatures)

1.7.3 Noise
Noise has been described as undesired sound. Normal permissible value for continuous eight hours exposure to noise has been recommended to the maximum of 90 dB. In situations where the noise level is high, workers get ill effects.

Auditory ill effects
- Temporary noise induced hearing loss
- Permanent hearing loss

Non-auditory ill effects
- Speech interference
- Variation in Blood Pressure
- Dilation of pupils
- Diseases like peripheral
- Vascular disturbances
- Vascular neuropathy
- Myopathy

Noise control measures
- Solid foundation of machines and use of rubber padding
- Proper maintenance of machine
- Installation of suitable sound absorbers
- Lining of walls and ceiling by acoustic boards
- Use of personal protective equipment like ear muffis, ear plugs
- Introduction of hearing conservation program
1.7.4 Vibration
Vibration is causing ill effects in the range of (30 – 400 Hz) less than 3 Hz the whole body vibrates and ill effect is mainly motion sickness. In industrial situations the ill effects are usually due to continuous handling of vibrating tools. The disorders appear due to local irritant and damaging action on the tissue and on the receptors embedded on them. Effect depends on the physical characteristics of the fluctuation process and the duration of conduct.

Vibration disease
Prolonged exposure to vibration leads to this disease which manifest in white finger due to vascular insufficiency when the factor is affecting locally. If the whole body vibrates changes such as poly-neuritis appear. To prevent this disease and related ill effect automation; remote control system should be introduced. The environmental permissible value of vibration should be maintenance and medical control like pre-employment and periodic examination should be carried out.

1.7.5 Illumination
The man is having a high position; the evolutionary scale due to accuracy of sight, the accuracy of thumb and finger movement and the coordination of the eye and hand by the brain are very important. This biological fact alone makes the importance of illumination in day to day work. The standard light (illumination) is described in unit called lux. The ill effects due to defective illumination are accidents, eye fatigue and head-ache. Stimulation of A.N.S. is also reported. Glare can cause visual discomfort and irritability. Ideally the glare index should be from 12 to 20.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Canteen</td>
<td>150</td>
</tr>
<tr>
<td>Aircraft</td>
<td>300-450</td>
</tr>
<tr>
<td>Engine assembly</td>
<td>300</td>
</tr>
<tr>
<td>Radio telephone assembly</td>
<td>700</td>
</tr>
<tr>
<td>Foundries</td>
<td>150-300</td>
</tr>
<tr>
<td>Iron and steel works</td>
<td>100-300</td>
</tr>
<tr>
<td>Steel metal works</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 1.5 Recommended value of illumination in lux

1.7.6 Colour Scheme
No lighting scheme can be full effective without the proper colour application. In industries colours are used for:
- Improving quality of workmanship
- Reducing rejection
- Reducing accidents
- Rising house keeping
- Reducing absenteeism
- Improving morale of the workers

Adverse effects of colour on health of the people are mainly through its psychological effects. Each colour gives a special psychological appreciation on the human and moderates the behaviour accordingly. If this is not in the proper shape ill effects increase.
<table>
<thead>
<tr>
<th>Colour</th>
<th>Psychological effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Stimulates</td>
</tr>
<tr>
<td>Yellow</td>
<td>Freshening</td>
</tr>
<tr>
<td>Orange</td>
<td>Tension producing</td>
</tr>
<tr>
<td>Light green and blue</td>
<td>Relaxed feeling</td>
</tr>
<tr>
<td>Purple</td>
<td>Depression</td>
</tr>
<tr>
<td>White</td>
<td>Stimulating</td>
</tr>
</tbody>
</table>

Table 1.6 Psychological effects of colours

Size
Green and blue surface recedes.
Red and yellow comes forward.

Temperature
Red and yellow gives warm feeling.
Blue and green gives cool feeling.
These points have to be kept in mind while planning the work so that ill effects due to colour do not occur.

1.7.7 Ionising Radiation
Radiation can effect the people according to whether it comes from outside or from inside the body. The amount of tissue damage in exposed persons depend on the energy absorbs per unit mass of tissue and the nature of organic tissue itself. The blood forming organs and reproductive organs are more sensitive to radio active substances. Radiation absorbs by the tissue is measured in rads. One rad corresponds to hundred ergs and energy/gram of tissue.

1.7.8 Alpha Particles
This is used in industries to monitor the thickness of paper, polythene films etc. These are high energy particles with very low penetrating capacity. The ill effects are mainly minor burns in the vicinity.

Beta rays
They are electrons of various energies and penetrate few millimeters into the tissue before they are absorbed. They cause some deep damage to the tissue.

Gamma rays and X-rays
They are electromagnetic radiations of energies. They are used for metal inspections and welding checks. They have power of high penetration and are very dangerous. They cause burn, dermatitis locally and skin cancer, leukemia and germ mutation systematically.

Neutrons
They are uncharged particles with a wide range of energy and power of penetration. They cause remote and severe damage to the tissues.

Permissible doses of radiation
International commission on radiological protection recommends:
- Three Rms during any period of 13 consecutive weeks to the testes or ovaries, blood forming organs and lenses of eye at any over 18 years.
- 235 Rms of whole body radiation for persons occupationally exposed from 18 to 65 years age.
Principles of protection against radiation:

• Exposure must be minimised.
• Shielding to be adopted.
• Change direction of radiation beam towards safe area.
• Adequate records.
• Medical examination with a special attention to blood.
• Technical protection measures and follows up of regulations regarding storage, use, monitoring and disposal.

1.7.9 Non Ionising Radiation

Ultra-violet radiation
Ultra violet radiation affects the skin causing burn, skin cancer and conjunctivitis. In welders it may cause “Arc eye”.

Infrared radiations
Eye suffers more damaging effects due to this. They may cause fatigue and headache and cataract. Glass blowers cataract is the commonest example.

Microwaves radiation
Cornea and lens of eye are the most vulnerable structures because of the lack of heat dissipating blood vessels. Cataract and skin burns are similar to the infrared radiation. The frequency of more than 30 MHz is dangerous.

Laser Beams
A laser beam is a beam of light energy of one length and a phase in which waves trouble together in step and in rhythm. Its application in cutting and welding operations, in photography and in medical use for photo coagulation of retina is well-known. Organ effects are mostly to the eye.

1.7.10 Air Pressure

High air pressure
In operations like tunneling, diving the high air pressure is heeded. When the person returns to normal air pressure the problem like pain in muscles, bones and joints are felt. Ear, tooth pains can also be experienced due to the decompression phenomenon. Preventive measures require careful and gradual time bound decompression process.

Low air pressure
Lack of oxygen can lead to blocking out or the behavioral changes in pilots without pressurised cabins at high altitudes. Oxygen mask should immediately be used in such condition.

1.8 Layout and House-keeping

If the layouts are not made properly the health hazards may appear. For example, if a canteen is situated near toilet or near the workplace, where toxic gases are emitted the ill effects may become a problem. Therefore, planning and making good layout is necessary. Similarly good housekeeping prevents majority of accidents at workplace.
Summary

- Occupational Health is a specialised branch of preventive medicine, which deals with not only prevention of occupational disease but also enhancement of the present state of health of workers in order to increase work-efficiency and productivity.
- It is necessary that each worker needs to be medically monitored for assessing the state of his health.
- The aim of pre-employment medical examination is not to declare any one fit or unfit but to select the right person for the right job.
- The periodic health examination would include the critical organ evaluation to prevent increasing body burdens to the work environment.
- Heat and cold represent opposite extremes of body temperature and occupational hazards are encountered in both the situations.
- Prolonged exposure to vibration leads to this disease which manifest in white finger due to vascular insufficiency when the factor is affecting locally.
- The amount of tissue damage in exposed persons depend on the energy absorbs per unit mass of tissue and the nature of organic tissue itself.

References


Recommended Reading

Self Assessment

1. By definition, healthy workplace is also a __________ workplace.
   a. safe
   b. hygienic
   c. happy
   d. good

2. Which of the following is an important factor for an employee to work at his/her best?
   a. Distance of workplace from his home
   b. Economic satisfaction of earning a livelihood
   c. Other facilities he is getting from the job
   d. Timings of the job

3. The ______ defines health as a state of physical, mental, social and spiritual well being and not just an absence of disease and/or infirmity.
   a. Government
   b. Health minister
   c. WHO
   d. HOW

4. ____________ is a specialised branch of preventive medicine, which deals with not only prevention of occupational disease but also enhancement of the present state of health of workers.
   a. Psychological health
   b. Physiological health
   c. Occupational management
   d. Occupational Health

5. ____________ are those which may arise out of or in the course of employment.
   a. Occupational diseases
   b. Occupational stress
   c. Occupational hazard
   d. Occupational imbalance

6. The state of ________ of worker can influence his ability to work safely and efficiently.
   a. time
   b. money
   c. health
   d. place

7. ____________ are uncharged particles with a wide range of energy and power of penetration.
   a. Gama rays
   b. Neutrons
   c. Alpha rays
   d. Beta rays
8. __________ are high energy particles with very low penetrating capacity.
   a. Infrared radiations
   b. Laser beams
   c. Ionising radiation
   d. Alpha particles

9. The aim of __________ is not to declare any one fit or unfit but to select the right person for the right job.
   a. pre-employment medical examination
   b. pre-employment physical examination
   c. pre-employment stress test
   d. pre-employment cardio examination

10. In industries, _______ are used for improving quality of workmanship.
    a. lights
    b. air conditioners
    c. colours
    d. themes
Chapter II
Occupational Health Services and Chemical Hazards

Aim
The aim of this chapter is to:

• define the services of an occupational health centre
• discuss the method of how to set up a functional occupational health centre at workplace
• explain chemical hazards at workplace

Objectives
The objectives of this chapter are to:

• define scope of occupational health services
• explain basic and specific functions
• describe examination for chemical hazards

Learning outcome
At the end of this chapter, you will be able to:

• explain category of fitness post PHE
• define control of chemical hazards
• classify chemical agents
2.1 Introduction

Occupational health care is a process, not an outcome, and the success and quality of a service providing such care is measured by the absence of problems rather than by a specific end point. Organisations as different as small business, corporations, government agencies, and the military have similar needs for effective occupational health services. The term “occupational health service” is used in writing and speech. When singular, the term usually refers to a facility or a department or other administrative unit charged with responsibility for occupational health and usually safety as well. When plural or when specified as one of several opportunities, the term usually means an activity, program, or function in the sense of a service to be provided. Occupational health encompasses many programs of inspection, medical surveillance, and education. One of the major elements of occupational health is industrial hygiene, which is concerned with the identification, evaluation, and elimination or reduction of health hazards associated with the work environment.

Role of occupational health service

The role of the occupational health service is to provide assistance both to management and the employee so that the employee is not harmed in the course of work. To fulfil this role, the service must be perceived to be objective and impartial, whether it is part of the management structure or an external health care provider. The operational responsibility for sound occupational health and safety practice lies with the people who do and supervise the work, the employee, operating personnel, and managers. The occupational health service exists to serve them; it can assist but it cannot be in all places at all times.

Objectives of occupational health service

The objectives of an occupational health service can be summarised as follows:

• To provide leadership, support, and technical services to the employer and the employee in all areas relating to health and safety in the workplace.
• To develop standards, procedures, reporting systems, and policies necessary to promote sound occupational health and safety practices, and to monitor compliance with them.
• To evaluate, to treat, and to limit temporary or permanent disability resulting from injury or illness occurring in the workplace.
• To detect significant health hazards as early as possible and to assist the managers responsible for the working unit and the employee in correcting the hazard before an injury or illness results.
• To assist the employee in controlling personal health problems and living a healthy life, in order to enhance their quality of life, productivity, and well-being.

2.2 Scope and Functions of Occupational Health Services

The functions and scope of occupational health services can be described as follows:

Scope of occupational health services

Occupational health providers can offer more than just on-site healthcare services. Many of them offer other health-related benefits (through strategic partnerships) that, if implemented for a particular employer, are integrated into the employee health offering. These health services can include health promotion, disability management, disease management and more. For the HRO (Human Resource Outsourcing) provider, aggregation of these services can facilitate data integration, leading to a considerably more efficient implementation of services. When presented with this option, employers have the ability to select from a broad range of previously integrated health-related services that have been inspected by the HRO organisation.

• Functions of occupational health services
  • The functions of an occupational health service are to protect and promote the health of the workers.
  • Improve the working conditions and environment and maintain the health of the enterprise as a whole by providing occupational health services to workers.
  • Suggesting employer on how to achieve the highest possible standards of health and safety in the interest of the particular working community of which it is a part.
An occupational health service should establish a programme of activities adapted to the needs of the enterprise where it operates and performs its functions in accordance with it.

The functions should be adequate and appropriate to the occupational hazards of the enterprise it serves, with particular attention given to the problems specific to the branch of economic activity concerned.

### 2.3 Assessment of Work Environment

The evaluation of health hazards in the workplace should be accomplished by considering the complete picture of exposures in comparison with established occupational exposure standards. Such standards are expressed in terms of permissible levels and exposure limits and are set up through numerous scientific studies correlating exposure with produced health effects.

- Assessment in the working environment includes monitoring both the hazardous exposures and the health outcomes.
- If exposure to hazards is excessive, it should be controlled regardless of outcome, and the health of exposed workers should be evaluated.
- Exposure is considered excessive if it approaches or exceeds established limits.
- Surveillance of the work environment provides information on the occupational health needs of the enterprise and indicates the priorities for preventive and control actions.
- Most of the instruments guiding occupational health services emphasise the need to carry out an investigation before initiating services, periodically during the course of the activities, and always when substantial changes in work or the working environment have taken place.
- The results obtained provide the necessary data to estimate whether preventive actions taken against health hazards are effective, also whether workers are placed in jobs adequate to their capacities.

#### 2.3.1 Advice on Preventive and Control Measures

Occupational health services should propose appropriate prevention and control measures for the removal of hazardous exposures and for protecting worker’s health. Control measures should be satisfactory to prevent unnecessary exposure during normal operating conditions and during possible accidents and emergencies as well. Guidelines for preventive actions for management and control of health and safety hazards and risks are:

- control of hazards at the source
- ventilation or control technology
- dust control
- ergonomic measures
- use of personal protective equipment
- regulation of thermal conditions

#### 2.3.2 Record Keeping

Basic Occupational Health Services have a general obligation to keep record on health services provided to the workers. The record-keeping obligations are:

- General health record if the workers are treated as patients or health service clients.
- Data on surveyed, detected and measured occupational exposures and risk assessments which have been made.
- Statistics on occupational diseases and injuries.
- Data on health examinations.
- Documents on proposals for preventive and control measures.
There is no trade-off between health and productivity at work. The idea of providing basic occupational health services deserved special attention, as it would provide countries with a practical tool for identifying priorities and pooling scarce resources to develop an integrative and effective occupational health system and services, customised according to the national conditions and needs of each country.

Industrial hygiene surveys will be conducted by industrial hygiene personnel to evaluate operations or practices involving actual. The evaluation of exposures will include operations that have:

- Chemicals
- Pesticides
- Radiation, (ionising and non-ionising)
- Noise hazards
- Eye hazards
- Biological hazards
- Ergonomic hazards (human/operation interface)
- Other environmental conditions

### 2.4 Health Examinations

Health examinations constitute the basic element of an occupational health program. Such examinations include pre-placement, periodic job related, and administrative examinations together with voluntary health maintenance examinations, as personnel and other resources permit. In many instances, the health examinations may not require extensive physical examination by a physician. It may be accomplished most expeditiously by the occupational health nurse with appropriate minimal input from the occupational health physician. Such delegation of functions facilitates optimal use of the professional skills of both the physician and the nurse.

- **Pre-placement examinations** may be required for new hires, job transfers, overseas assignments, or promotions. The new employee should be referred to the occupational health services for processing and initiation of the medical record. At this time, the employee should be provided, or scheduled for a baseline health screening to include a health history, audiogram, vision screening, and blood pressure reading.

- **Periodic job-related examinations** are an essential component of the health examination program. The inventory of health hazard assessments is the basis for this program because the examination will be specific to the exposure, operation, or physical fitness requirements involved.

- **Administrative examinations** cover fitness for duty, disability retirements, and other administrative health examinations will be provided as needed.
Voluntary health maintenance examinations are of value for the early detection of disease and consequent reduction in disability. Such examination may be provided when resources permit and may be accomplished in a number of ways, including the use of the nursing. Accordingly, any examination, which can reduce absenteeism and promote health, is cost effective.

Physical examination coordination covers all occupational related examinations for active duty (AD) military and civilian employees. It should be coordinated through the occupational health service to ensure performance of all required tests and review of results with referral to the occupational health physician as indicated.

A follow-up system should be developed and maintained for all health examination and screening programs to identify and report on their effectiveness and ensure indicated counselling and referral support.

Treatment of illness and injuries

The care of the acutely ill and injured is another principal element of an occupational health program. Civilian employees on TDY as well as personnel assigned to the local installation are eligible for such treatment.

Job-related illnesses and injuries

Employees with job-related illnesses and injuries are provided emergency and follow-up care in accordance with AR 40-3 and AR 40-5. In cases of traumatic injury, a specific determination will be made and noted on appropriate U.S. Department of Labor Compensation (USDLC) forms as to the degree and probable duration of disability.

Non-occupational illnesses and injuries provide emergency treatment or limited soothing treatment of non-occupational conditions is authorised by AR 40-5 and will be provided to prevent loss of life, relieve suffering, or reduce absenteeism. Employees requiring definitive treatment of non-occupational health problems should be referred to their personal physician or other appropriate health resources.

Emergency care after duty hours are provided for medical care of emergencies during non-duty hours of the MTF, if individuals are employed on other than normal day shifts.

First aid kits are utilised when professionally staffed and appropriately equipped health care facilities are readily available is not in the best interest of the employee. This practice also results in failure to report occupational injuries and loss of epidemiological data. If local medical personnel determine that first aid kits are needed at certain work areas, injuries incurred and treatments given will be reported to health clinic personnel for recording in the employee’s medical record.

Illness absence monitoring

A policy of encouraging referral of employees to the occupational health clinic prior to leaving work because of illness will be considered. Benefits to be derived from such a policy include appropriate disposition of ill employees, opportunities for health education, and increased awareness on the part of occupational health personnel of the types of health problems employees are having. Additionally, man-hours can be conserved if soothing treatment is given for an acute minor illness before it becomes serious so that the employee is able to remain on the job.

Policies related to health clearance of employees prior to returning to work after illness or injury should be determined by the nature of the work performed, the individual health needs of the employee, the supervisor’s recommendations, and the capabilities of the occupational health staff. Interviewing employees following a significant illness or injury helps to bring employees with special health problems to the attention of occupational health personnel and ensures that employees do not return to work before they are able. Special requirements for clearance will be instituted for employees engaged in patient care and food service activities to ensure that these individuals do not return to work when capable of transmitting a communicable illness.

Chronic Disease or Disability Surveillance: Employees with chronic disease or disability should be identified through such procedures as a review of Standard Form (SF) 177, routing medical examination, or mass screening programs. The OH staff will maintain a list of all chronically ill or disabled persons that could affect or be affected by their work assignments. Medical records of such personnel should be coded and include relevant clinical information regarding the patient’s condition and the name of his/her private physician.
• Immunisation program: Appropriate immunisations should be provided to employees potentially exposed to infectious disease because of the work environment or required foreign travel.

**Employees health education**

Factors such as the type of work performed, the nature of hazards found in the work environment, and distinctive characteristics of the work force should form the basis of health education programs.

- Educational activities may be divided into two categories:
  - Those concerned with health implications of the job
  - Those related to general health maintenance and health promotion

- The OSH Act and the DOD OSHA criteria require that employees be apprised of identified health hazards to which they are exposed, relevant symptoms, appropriate emergency treatment, and responsibility for using protective clothing or equipment. Additionally, provisions should be made for providing employees information concerning occupational health services. Supervisors should be provided initial and periodic orientation and guidance regarding their responsibilities for the health of employees and areas for coordination with the OH staff.

- Hearing Conservation Program: The prevention of hearing loss from exposure to noise requires identification and evaluation of noise-hazardous areas and/or equipment. Posting of these same noises hazardous areas with appropriate caution signs, installing engineering control measures, and using hearing protection devices may be necessary. Pre-placement and periodic monitoring the audiometer of personnel identified as working in noise hazardous areas supplemented by health education and supervision and discipline of personnel may be in order.

- Inspections: All workplaces, including offices, will be inspected at least once annually to determine if any unsafe or unhealthy conditions exist. In depth surveys performed by USAEHA will complement the inspections and provide an excellent health hazard data base for follow-up surveys and inspections. If a condition exists that cannot be evaluated by medical personnel, a request for support should be submitted through the established support channels. Every effort should be made to coordinate all occupational health and/or industrial hygiene surveys and inspections with the respective safety offices.

**2.5 Introduction to Industrial Hygiene**

Industrial hygiene (IH) is the science and art devoted to recognition, evaluation, and control of those environmental factors or stress, arising in or from the work place, which may cause sickness, impair health and well being, or cause significant discomfort and inefficiency among workers or among the citizens of the community. Industrial hygiene primarily involves:

- The recognition of environmental hazards and stresses associated with work and work operations, and the understanding of their effects on man and his well being in the work place and the community.
- The quantitative evaluation, through training and experience, of the magnitude of these hazards and stresses is to determine the actual potential for harm to man’s health and well being.
- The prescription of methods to control or reduce such factors and stresses when necessary to alleviate their effects.

**Recognition** of environmental hazards and stresses that influence health requires a familiarity with work operations and processes. The categories of hazards are:
### Chemical hazards
- Chemical in the form of liquid, dust, fumes, mist, vapour, or gas.

### Physical hazards
- Physical energy, such as electromagnetic and ionising radiation, noise and vibration, and extremes of temperature and pressure.

### Biological hazards
- Biological, such as insects and mites, moulds, yeasts, fungi, bacteria, and viruses.

### Ergonomic hazards
- Ergonomic, such as body position in relation to task, monotony, boredom, repetitive motion, worry, work pressure, and fatigue.

The effect of these four areas of stress on man’s health and well being must be recognised. It is important to know whether such stresses are dangerous to life and health, whether they produce an acceleration of the aging process, or whether they will cause only significant discomfort and inefficiency.

**Evaluation** of the magnitude of the environmental factors or stresses arising in or from the work place is essential in order to predict the probable effect on health and well being. The industrial hygienist, by virtue of training and experience and aided by quantitative measurements of the chemical, physical energy, biological, or ergonomic stresses, can render an expert opinion as to the “healthfulness” of the environment, either for short periods or for lifetime exposure.

### 2.6 Prescription of Corrective Procedures
Prescription of corrective procedures is necessary to protect health, and when controlling measures are based on a good evaluation of the environmental factors of stresses. The control measures which are most frequently used are:
- Isolation of a process or work operation to reduce the number of persons exposed.
- Substitution of a less harmful material for one that is more dangerous to health.
- Alteration of a process to minimise human contact.
- Ventilation and air cleaning to provide an atmosphere safe for human occupancy.
- Reduction of exposure to radiant energy by shielding, increasing distance, and limiting time.
- Wet methods to reduce emission of dusts to the atmosphere such as in abrasive blasting, lathing, and grinding operations.
• Good housekeeping, including cleanliness of the work place, proper waste disposal, adequate washing, toilet and restroom facilities, healthful drinking water and eating facilities, and control of insects and rodents.
• Personal protective devices to be worn, such as special clothing, eye, hearing, and respiratory protective equipment

**Worker education training**
A program of education and orientation of new employees to acquaint them with the potential hazards in the work place is a joint IH, safety, and supervisory responsibility. Close coordination between responsible personnel, employee representatives, and employees is necessary to ensure that employees are specifically informed about potential hazards, preventive measures, and proper cooperation of process and control equipment. Safety personnel have access to numerous publications on worker training and should be asked for help in establishing a safety program.

### 2.7 The Phases of Industrial Hygiene
The industrial hygiene programs normally consist of three phases namely recognition, evaluation, and control. These phases will assist you to reduce those environment factors that detract from employee well being and to create a better work environment or physical and physiological work environment.

- **Recognition**: Health hazards in the work area must first be recognised. This will usually be the result of various surveys, inspections, and inventories, which you will make. It can also result from listening to complaints received from workers or by noting trends reflected in written reports.

- **Evaluation**: The hazards present in the work environment must be evaluated in terms of their long term, as well as their short term effects on employees’ health. This evaluation will be based on all data available, from inspections and surveys, as well as from experience and technical knowledge.

- **Control**: The last phase is the development, implementation, and follows up on corrective measures that will reduce or eliminate the existing health hazards. Control measures may include:
  - **Replacement**: replacement of toxic or harmful substances with less dangerous ones.
  - **Modification**: modification of work processes or procedures to minimise or eliminate worker exposure.
  - **Ventilation**: utilisation of ventilation to reduce the concentration of harmful substances to safe levels.
  - **Distance**: increasing the distance between the worker and the source of the harmful substance or the noise.
  - **Protection**: requiring the use of personal protective equipment or clothing.
  - **Isolation**: isolation of a process of work operation to reduce the number of persons exposed.
  - **Wet methods**: using wet methods to reduce emission of dusts to the atmosphere such as in case of abrasive blasting, lathing and grinding operations.
  - **Housekeeping and cleanliness**: good housekeeping includes cleanliness of the work place, proper waste disposal, adequate washing of toilets and rest room facilities, healthy drinking water facilities and control of insects and rodents.

### 2.8 Chemical Hazards
There is hardly any industry which does not make use of chemicals. The chemical hazards are on the increase with the introduction of newer and complex chemicals. Chemical agents act in three ways which are local action, inhalation and ingestion. The ill-effects produced depend upon the duration of exposure, the quantum of exposure and individual susceptibility.

#### Local action
Some chemicals cause dermatitis, eczema, ulcers and even cancer by primary irritant action; some cause dermatitis by an allergic action. Some chemicals, particularly the aromatic nitro and amino compounds such as TNT and aniline are absorbed through the skin and cause systemic effects. Occupational dermatitis is a big problem in industry.

#### Inhalation
It covers the following important factors:

- **Dust**
  - Dusts are finely divided solid particles with size ranging from 0.1 to 150 microns.
  - They are released into the atmosphere during crushing, grinding, abrading, loading and unloading operations.
  - Dusts are produced in a number of industries e.g., mines, foundry quarry, pottery, textile, wood or stone working industries.
  - Dust particles larger than 10 microns settle down from the air rapidly, while the smaller ones remain suspended indefinitely.
  - Particles smaller than 5 microns are directly inhaled into the lungs and are retained there.
  - This fraction of the dust is called respirable dust, and is mainly responsible for pneumoconiosis.
  - Dusts have been classified into inorganic and organic dusts; soluble and insoluble dusts.
  - The inorganic dusts are silica, mica, coal, asbestos dust, etc. whereas, organic dusts are cotton, jute etc.
  - The soluble dusts dissolve slowly, enter the systemic circulation and are eventually eliminated by body metabolism.
  - The insoluble dusts remain, more or less, permanently in the lungs.
  - They are mainly the cause of pneumoconiosis. The most common dust diseases are silicosis and anthracosis.

- **Gases**
  - Exposure to gases is a common hazard in industries.
  - Gases are sometimes classified as simple gases (e.g. oxygen, hydrogen), asphyxiating gases (e.g. carbon monoxide, cyanide gas, sulphur dioxide, chlorine) and anaesthetic gases (e.g. chloroform, ether, and trichlorethylene).
  - Carbon monoxide hazard is frequently reported in coal-gas manufacturing plants and steel industry.

- **Metals and their compounds**
  - A large number of metals and their compounds are used throughout industry.
  - The chief mode of entry of some of them is by inhalation as dust or fumes.
  - The industrial physician should be aware of the toxic effects of lead, antimony, arsenic, beryllium, cadmium, cobalt, manganese, mercury, phosphorus, chromium, zinc and others.
  - The ill-effects depend upon the duration of exposure and the dose or concentration of exposure.
  - Unlike the pneumoconiosis, most chemical intoxications respond favourably to cessation, exposure and medical treatment.

### Ingestion

Occupational diseases may also result from ingestion of chemical substances such as lead, mercury, arsenic, zinc, chromium, cadmium, phosphorus, etc. Usually these substances are swallowed in minute amounts through contaminated hands, food or cigarettes. Much of the ingested material is excreted through faeces and only a small proportion may reach the general blood circulation.

### 2.9 Occupational Health Hazards at Workplace

Occupational health aims at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention amongst workers of departures from health caused by their working conditions; the protection of workers in their employment from risk resulting from factors adverse to health; the placing and maintenance of workers in an environment adapted to their physiological and psychological capabilities. The ultimate objective of occupational health is a healthy, safe and satisfactory work environment and a healthy, active and productive worker, free from both occupational and non-occupational diseases. The oil and gas industry is potentially more hazardous than many other industries as it has many diverse activities, including
processes, operations and materials which can pose risks to health, safety and the environment. As a result of these, workers are exposed to large number of hazards such as physical, chemical, biological and psychological hazards that can pose a potential risk to health and wellbeing. Occupational health should aim at:

- The promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations.
- The prevention amongst workers of departures from health caused by their working conditions.
- The protection of workers in their employment from risks resulting from factors adverse to health.
- The placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological capabilities.

Occupational health hazards are classified as:

<table>
<thead>
<tr>
<th>Occupational health hazards</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical health hazards</td>
<td>Noise, heat, cold vibration, radiation</td>
</tr>
<tr>
<td>Chemical health hazards</td>
<td>Exposures to chemicals like metals, gases, pesticides, solvents</td>
</tr>
<tr>
<td>Biological health hazards</td>
<td>Snake bites anthrax, hay fever, HIV and other infections</td>
</tr>
<tr>
<td>Psychosocial health hazards</td>
<td>Occupational stress, job satisfaction, absenteeism, alcoholism, debt, addictions</td>
</tr>
</tbody>
</table>

Table 2.1 Classification of occupational health hazards

2.10 Route of Absorption

The harmful effects of chemical substances depend on the toxicity and the exposure to that chemical. The level of exposure depends on the concentration of the hazardous chemical and the duration of exposure. Many substances do not give any warning by odour, even though they may be present at dangerous concentrations in the workplace air. Usually one or two organs are most affected. These are referred to as target organs of toxicity of the particular substance. The central nervous system is the target organ of toxicity most frequently involved in systemic effects. Following are some important organs which get badly affected:

- **Skin** is the largest organ in the human body, 1.5-2 m² in area. It provides a protective cover to the body but can fail if the load is overwhelming. A number of substances can penetrate healthy intact skin and enter the blood circulation. Phenol is a substance that may even result in death after exposure and penetration through the skin. Diseases related to skin are contact eczema, irritation and inflammation of the skin. This condition can either be non-allergic or allergic reaction of exposure to chemical substances. Several colorants and dyes, metals such as nickel and its salts, chromium and cobalt salts and organ mercuric compounds, monomers of a number of acrylates and rubber additives are examples of common contact sensitisers.

- The **lung** is the major route through which toxic substances enter the body in the workplace. It is also the first organ to be affected by dusts, metal fumes, solvent vapours and corrosive gases. Allergic reactions may be caused by substances such as cotton dust, TDI (toluene diisocyanate, used in the manufacture of polyurethane plastics), and MIC (methyl isocyanate, used in production of carbaryl insecticide). Allergic reactions may result also from exposure to bacteria or fungi: this is the case in allergies from handling stocked hay (‘farmer’s lung’) or dried sugar cane. When dust particles of a certain size of some substances are inhaled the lungs are unable to remove them. The particles become embedded in the lungs causing a condition called pneumoconiosis. It is a specific problem for workers exposed to the dust of silica (quartz) and asbestos, and is the most common non-malignant occupational lung disease throughout the world. Other substances, such as formaldehyde, sulphur dioxide, nitrogen oxides and acid mists, may cause irritation and reduce the breathing capacity.

- The **nervous system** is sensitive to the hazardous effects of organic solvents. Some metals affect the nervous system, especially heavy metals such as lead, mercury and manganese. Organophosphate insecticides such as malathion and parathion interfere severely with information transmission (chemical neurotransmitter function) in the nervous system, leading to weakness, paralysis and sometimes death.
• The **blood circulation** is a target for the adverse effects of solvents. Blood cells are mainly produced in the bone marrow. Benzene affects the bone marrow; the first sign is mutation in the blood cells called lymphocytes. Lead, in the form of the metal or its compounds, is another classic example of a chemical that may cause blood problems. Lead in the blood may inhibit certain enzyme activities involved in the production of hemoglobin in red blood cells. Chronic lead poisoning may result in a reduced ability of the blood to distribute oxygen throughout the body, a condition known as anemia.

• The **liver**, the largest of the internal organs of the body, has several important functions. It is a purification plant which breaks down unwanted substances in the blood. The liver has a considerable reserve capacity; symptoms of liver disorder appear only in serious diseases. Solvents such as carbon tetrachloride, chloroform and vinyl chloride, as well as alcohol are hazardous to the liver.

• The **kidneys** are part of the body’s urinary system. They have the task of excreting waste products that the blood has transported from various organs of the body; of keeping the fluids in balance and of ensuring that they contain an adequate blend of necessary salts. They also maintain the acidity of the blood at a constant level. Solvents may irritate and impair kidney function. The most hazardous to the kidneys is carbon tetrachloride. Turpentine in large quantities is also harmful to the kidneys: ‘painter’s kidney’ is a known condition related to occupational exposure. Other well-known kidney-damaging substances are lead and cadmium.

---

![Human organs badly affected by chemical substances](image)

**Fig. 2.3 Human organs badly affected by chemical substances**

A Safety Committee should be formed with the task of working regularly with safety issues. It could start to work with following:

**Organisational measures**

- identify chemicals in use
- obtain information of their hazards
- collect this data and make an inventory list of all chemicals used in the factory
- create a register for workplace chemicals
- assess chemical hazards and set priorities concerning the safety in the organisation
- create emergency plans for the assessed hazards
- organise occupational health care and regular surveys when necessary
- organise contacts with authorities/laboratories to create a monitoring system for chemical hazards and to reliably measure and/or estimate occupational exposures to chemicals when needed
- start collecting case studies of accidents and sickness records in the enterprise to create a basis for priority measures in the control of hazards
- involve workers in safety organisations, such as the system of Safety Representatives, and Safety Committees
- technical measures to control the hazard
- technical measures can be used to prevent chemical hazards at source. By technical means it is possible to reduce the exposure of the worker
Substitution
- An effective control method for any hazardous chemical is substitution: a hazardous chemical is replaced with a less hazardous one. This is especially important when the chemicals in question can cause cancer, damage to the reproductive functions or create allergic reactions.
- Choosing a safer process or changing an old and hazardous process to a less dangerous one effectively reduces the risks.
- Route of exposure describes the way the chemical enters the body. Chemicals may have serious effects by one route, and minimal effects by another.

![Chemicals diagram]

Fig. 2.4 Effects of chemicals on health
2.11 Classification of Chemical Agents

The classification of chemical agents is shown below in the table.

<table>
<thead>
<tr>
<th>Chemical Agents</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td>lead, mercury, chromium, cadmium, zinc, manganese, arsenic, nickel, beryllium, uranium</td>
</tr>
<tr>
<td>Organic chemicals</td>
<td>• Aromatic carbon compounds Benzene, toluene, phenol</td>
</tr>
<tr>
<td></td>
<td>• Aliphatic carbon compounds Methyl, alcohol, nitroglycerine, glycol, vinylchloride</td>
</tr>
<tr>
<td></td>
<td>• Acyclic compounds</td>
</tr>
<tr>
<td>Inorganic chemicals</td>
<td>• Acids</td>
</tr>
<tr>
<td></td>
<td>• Alkalis</td>
</tr>
<tr>
<td></td>
<td>• Noxious gases</td>
</tr>
<tr>
<td></td>
<td>• Simple asphyxiants- ( \text{CO}_2, \text{N}_2\text{CH}_4 )</td>
</tr>
<tr>
<td></td>
<td>• Chemical-carbon monoxide, ( \text{H}_2\text{S}, \text{HCN} )</td>
</tr>
<tr>
<td></td>
<td>• Irritant gases- ( \text{SO}_2, \text{NH}_3, \text{Cl}_2, \text{COCl}_2 )</td>
</tr>
<tr>
<td></td>
<td>• Systemic poisons- ( \text{C}_2\text{S}_2, \text{phosphine, stibine} )</td>
</tr>
<tr>
<td></td>
<td>• Dusts- coal dust, silica, asbestos, cotton, flour etc.</td>
</tr>
</tbody>
</table>

Table 2.2 Classification of chemical agents
## 2.12 Organs/Systems Affected by Chemicals/Occupation

The table below shows the organs or systems affected by chemicals or occupation.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eyes</strong></td>
<td>Mercury, Glass blowers, furnace operators, Acids and Alkalis, Fumes, Cyanoacrylates</td>
</tr>
<tr>
<td><strong>Mouth, lips, tongue</strong></td>
<td>Chrome ulcers, yellow discoloration by H2SO4</td>
</tr>
<tr>
<td><strong>Teeth</strong></td>
<td>fumes, Blue line on gums due to lead, Bleeding gums and falling of teeth due to Cyanoacrylates</td>
</tr>
<tr>
<td><strong>Nasal cavity</strong></td>
<td>Perforation of nasal septum in chromium</td>
</tr>
<tr>
<td><strong>Skin</strong></td>
<td>Arsenic, Cutting oils, Organic solvents, Coal tar, Epoxy Resins</td>
</tr>
<tr>
<td><strong>Bone</strong></td>
<td>Phosphorus, Fluorine</td>
</tr>
<tr>
<td><strong>Bone-marrow</strong></td>
<td>Benzene, explosive, distilleries ,dyes</td>
</tr>
<tr>
<td><strong>Liver</strong></td>
<td>Organic solvents, Alcohol ,Vinyl chloride(anagiosarcoma of liver), Tanning Smelting, Plastic industries, Carbon tetrachloride</td>
</tr>
<tr>
<td><strong>Lungs</strong></td>
<td>Asbestos, Silica, Organic dusts, Chrome, Coal, Iron oxide, Nickel, Mustard gas, Petroleum industries, Ammonia, Chlorine</td>
</tr>
<tr>
<td><strong>CNS</strong></td>
<td>Lead, Mercury, Manganese, Pesticides</td>
</tr>
<tr>
<td><strong>Endocrine system</strong></td>
<td>Pharmaceuticals industries manufacturing OC pills</td>
</tr>
<tr>
<td><strong>Reproductive system</strong></td>
<td>Lead , Viscose rayon, Pesticides Ethyl Cellusolve, DBCP</td>
</tr>
<tr>
<td><strong>Digestive system</strong></td>
<td>Lead, Chemical Fumes in Adhesive Industries</td>
</tr>
<tr>
<td><strong>Urinary system</strong></td>
<td>Lead, Mercury, Blood in Urine due to Aniline dyes, Carbon Tetrachloride</td>
</tr>
<tr>
<td><strong>Cancer</strong></td>
<td>Vinyl Chloride in liver, Asbestos, Chrome, Cadmium, Arsenic in Lung cancer, Chimney soot in Scrotal cancer, Aniline dyes in Cancer of Urinary Bladder, Benzene in Blood Cancer</td>
</tr>
</tbody>
</table>

*Table 2.3 Dangerous chemicals and their effects on health*
2.13 Protective and Preventive Measures in Hazards Control

There are seven principles for protection and prevention of hazards:

1. Conducting a hazard analysis.
2. Identifying the critical control points (CCP).
3. Establishing critical limits for each critical control point.
4. Establishing critical control point monitoring requirements.
5. Establishing corrective actions.
7. Establishing procedures for ensuring the hazard control system is working as intended.

**Fig. 2.6 Seven principles for protection and prevention of hazards**

**Principle 1:** Conducting a hazard analysis. Plants determine the safety hazards and identify the preventive measures the plant can apply to control these hazards.

**Principle 2:** Identifying the critical control points (CCP). A critical control point (CCP) is a point, step or procedure in a manufacturing process at which control can be applied and thus a safety hazard can be prevented, eliminated, or reduced to an acceptable level.

**Principle 3:** Establishing critical limits for each critical control point. A critical limit is the maximum or minimum optimum value to which hazard must be controlled at a critical control point so as to prevent, eliminate or reduce to an acceptable level.

**Principle 4:** Establishing critical control point monitoring requirements. Monitoring activities is necessary for ensuring that the process is under control at each critical control point and within limits.

**Principle 5:** Establishing corrective actions. These are actions to be taken when monitoring indicates a deviation from an established critical limit or CCP is uncontrolled.

**Principle 6:** Establishing record keeping procedures. All plants should maintain certain documents, including its hazard analysis and documenting the monitoring of critical control points, critical limits, verification activities, and the handling of processing deviations.

**Principle 7:** Establishing procedures for ensuring the hazard control system is working as intended. Validation ensures that the plants do what they were designed to do within safety limits and they are successful in ensuring the production of safe product. Plants will be required to validate their own hazard control plans and these will be only reviewed.
While in some cases safety risk can be eliminated, in most cases a certain degree of safety risk must be accepted and in order to quantify expected accident costs before the fact, the potential consequences of an accident, and the probability of occurrence must be considered. Assessment of risk is made by combining the severity of consequence with the likelihood of occurrence in a matrix and risks that fall into the unacceptable category (e.g., high severity and high probability) must be mitigated by some means to reduce the level of safety risk.

### 2.14 Definitions

Following are some important terms related to chemical hazards:

- **Asphyxiant**: A chemical (gas or vapour) that can cause death or unconsciousness by suffocation. Simple asphyxiants such as nitrogen either use up or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulphide, interfere with the body’s ability to absorb or transport oxygen to the tissues.

- **Mutagen**: Anything that can cause a change (or mutation) in the genetic material of a living cell.

- **Narcosis**: Stupor or unconsciousness caused by exposure to a chemical.

- **Nuisance particulate**: Particulate that has a long history of little adverse effect on lungs and does not produce significant organic disease or toxic effect when exposures are kept under reasonable control.

- **Sensitiser**: A substance that may cause no reaction in a person during initial exposures, but afterwards, further exposures will cause an allergic response to the substance.

- **Suspect carcinogen**: A chemical known or suspected to cause cancer in animals or humans.

- **Systemic spread throughout the body**: Affecting many or all body systems or organs, not localised in one spot or area.

- **Teratogen**: An agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to that substance.

### 2.15 Surveillance in Chemical Hazards Control

One of the most complex issues the health and safety professional faces is how to recognise, evaluate, and control a chemical hazard. The figure given below is an aid to provide that help, it lists physical constants of many common industrial chemicals along with their relative fire and health hazards.
Purpose

To assess exposure of individual

To identify and quantify sources and processes creating hazards

Is toxic hazard

Acute? Chronic Cumulative?

Need to Assess

(Short term exposure) (Long term exposure)

Basis for evaluation

Preferred Technique

Control Systems

Can results be used to assess individual exposures?

Results used develop

What is time scale?

Direct reading instruments preferred

Fig. 2.7 Chemical hazards surveillance
Summary

- Occupational health care is a process, not an outcome, and the success and quality of a service providing such care is measured by the absence of problems rather than by a specific end point.
- The role of the occupational health service is to provide assistance both to management and the employee so that the employee is not harmed in the course of work.
- Occupational health services should propose appropriate prevention and control measures for the removal of hazardous exposures and for protecting worker’s health.
- One of the major elements of occupational health is industrial hygiene, which is concerned with the identification, evaluation, and elimination or reduction of health hazards associated with the work environment.
- Health examinations include pre-placement, periodic job related, and administrative examinations together with voluntary health maintenance examinations, as personnel and other resources permit.
- Factors such as the type of work performed, the nature of hazards found in the work environment, and distinctive characteristics of the work force should form the basis of health education programs.
- Industrial hygiene (IH) is the science and art devoted to recognition, evaluation, and control of those environmental factors or stress, arising in or from the work place, which may cause sickness, impair health and well being, or cause significant discomfort and inefficiency among workers or among the citizens of the community.
- Prescription of corrective procedures is necessary to protect health, and when controlling measures are based on a good evaluation of the environmental factors of stresses.
- The industrial hygiene programs normally consist of three phases namely recognition, evaluation, and control.
- The functions of an occupational health service are to protect and promote the health of workers and to improve working conditions and the working environment and maintain the health of the enterprise as a whole by providing occupational health services to workers.
- Assessment in the working environment includes monitoring both the hazardous exposures and the health outcomes.
- One of the most complex issues the health and safety professional faces is how to recognise, evaluate, and control a chemical hazard.

References

- Documentation of Threshold Limit Values. Cincinnati: American Conference of Governmental Industrial Hygienists.
- Boca Raton., Handbook of Chemistry and Physics. FL: CRC Press, Inc

Recommended Reading

Self Assessment

1. One of the major elements of occupational health is ________, which is concerned with the identification, evaluation, and elimination or reduction of health hazards associated with the work environment.
   a. industrial hygiene
   b. industrial safety
   c. physical hygiene
   d. occupational safety

2. The role of the occupational health service is to provide assistance to ____________.
   a. management
   b. management and employees
   c. employees
   d. employees and their family

3. As a health service ______________ have a general obligation to keep record on health services provided to the workers.
   a. WHO
   b. Basic Occupational Health Services
   c. Basic Occupational Stress Control
   d. Basic Occupational Services

4. Particles smaller than ______ are directly inhaled into the lungs and are retained there.
   a. 10 microns
   b. 2mm
   c. 0.5mm
   d. 5 microns

5. One of the most complex issues, the health and safety professional faces is how to recognise, evaluate, and control a ____________.
   a. chemical hazard
   b. natural hazard
   c. stress
   d. physical hazard

6. Which of the following statements is true?
   a. Choosing a safer process or changing an old and hazardous process to a less dangerous one effectively reduces the stress.
   b. Choosing a safer process or changing an old and hazardous process to a less dangerous one effectively reduces the hazard.
   c. Choosing a safer process or changing an old and hazardous process to a less dangerous one effectively reduces the risks.
   d. Choosing a safer process or changing an old and hazardous process to a less dangerous one effectively reduces the production.
7. ________ is the major route through which toxic substances enter the body at workplace.
   a. Nose
   b. Nostrils
   c. Throat
   d. Lung

8. ________ is the largest organ of a human body.
   a. Skin
   b. Lung
   c. Hair
   d. Intestine

9. ________ should be formed with the task of working regularly with safety issues.
   a. WHO
   b. Safety Committee
   c. Basic Occupational Health Services
   d. Basic Occupational Services

10. Which of the following statements is true?
    a. The most hazardous to the kidneys is turpentine.
    b. The most hazardous to the kidneys is carbon tetrachloride.
    c. The most hazardous to the kidneys is carbon dioxide.
    d. The most hazardous to the kidneys is carbon monoxide.
Chapter III
Dangerous Chemicals and Occupational Cancer

Aim
The aim of this chapter is to:

- define magnitude of the problem
- explain causative agents
- discuss the adverse health effects of dangerous chemicals

Objectives
The objectives of this chapter are to:

- elaborate control of occupational cancers
- analyse the recent development of occupational cancer in India
- explain manufacture and formulation of chemicals

Learning outcome
At the end of this chapter, you will be able to:

- discuss dangerous chemicals that cause cancer
- define types of occupational cancer
- classify the ways to control occupational cancer
3.1 Introduction

Harmful chemicals are everywhere, even in the home. Most of the time they do not cause a problem but, if they are used improperly it can be devastating. Chemicals can cause minor injuries, such as temporary rashes, to immediate death. Some chemicals cause harm immediately, while others appear to be harmless until years later when a disease pops up, e.g. lung cancer from asbestos. Occupational cancer is a form of delayed toxicity, usually serious in clinical course and outcome, due to exposure to chemical and physical agents (Carcinogens) in the workplace. The chief relevance of occupational cancer lies in the fact that occupational determinants of cancer once identified can be removed or controlled more easily than casual factors related to personal habits like smoking and other lifestyle factors.

3.1.1 Features of Occupational Cancer

The occurrence of cancer in workers exposed to certain physical and chemical agents is one of the most dramatic features of occupational pathology. In the workplace the primary route of exposure to a carcinogenic agent is through inhalation, although pollutant ingestion and skin contact can also be significant. The two situations which led to the discovery of a carcinogenic risk are:

- an unusual occurrence of a rare tumour in a working population (angiosarcoma of liver in polyvinyl chloride workers, pleural mesothelima in asbestos workers)
- an excess of a common neoplasia in a specific industrial process (lung cancer among employees in bis-methyl ether and chloro-methyl ether production lung cancer in mustered gas industry).

3.1.2 Effective Tools to Prevent Occupational Cancer

The effective tools to help prevent occupational cancer are:

- manufacturers must place warnings on dangerous products to alert the workers from cancer risks posed by a product
- respiratory protection can help protect workers from exposure to harmful respiratory carcinogens
- a worker must be warned about a hazard to become aware of the need to wear respiratory protection

Many hazardous substances, like asbestos, create invisible hazards. Asbestos is an example of a substance that has no natural warning properties. You cannot taste asbestos, you cannot smell it, and it can be present in harmful amounts that cannot even be seen by the naked eye. Even if the chemical is not odourless or is in plain view, the unfortunate truth is that many people who contract cancer from their workplace know they were exposed to the chemical but were unaware of cancer causing risks associated with it. A variety of occupational risks is known to cause cancer. You will not necessarily develop cancer just because you are exposed to a substance or process that causes cancer. Factors such as how you are exposed, how much you are exposed to, and for how long, also determine if you will develop cancer.

Chemicals can be in various forms: dust, fume, gas, mist, liquid, or vapor.

3.2 Safety Precautions

Reading warning labels and Material Safety Data Sheets (MSDS) is very important whenever one comes with the contact of any substance. General precautions include:

- If possible find an alternate safer product.
- Have proper ventilation systems.
- Never mix chemicals, unless they are designed for this.
- Limit exposure times.
- Wear personal protective equipment. This may mean full self-contained-breathing apparatus, during the product being used.
3.3 Causative Agents
Cancer may arise from various causes, one of which is the adverse effects of certain substances on cells in the body. The active agents can be the substances to which the body is exposed directly or ones formed during the metabolism of those substances in the body. Certain substances do not cause cancer directly, but may promote or initiate it on exposure to additional substances or agents. Cancer does not necessarily arise in the sites of the body where exposure first occurs.

3.4 Classification of Carcinogenic Substances
The main list of cancer-causing substances is produced by The International Agency for Research on Cancer (IARC). This list contains all hazards evaluated to date, according to the type of hazard posed and to the type of exposure. There are several groupings. It is believed that all substances in Group 1 and 2A should be removed from the workplace or, if that is not possible, exposure should be fully controlled. Caution should also be used to prevent exposure to substances in Group 2B.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>casually associated with the cancer in human</td>
<td>casually associated probably carcinogenic to human</td>
</tr>
<tr>
<td>2 A</td>
<td>2 B</td>
</tr>
<tr>
<td>High degree probability</td>
<td>lower degree probability</td>
</tr>
</tbody>
</table>

Table 3.1 Classification of carcinogenic substances

3.5. Diagnosis
Establishment of a specific case of cancer as occupational in origin is difficult as it has no specific identifying characteristics. Tumours of occupational origin have the same pathological features as those which appear to arise spontaneously and they have the same symptoms. However, they all have the following common characteristics:

- They tend to appear at an early age than spontaneous tumours of the same sites.
- Therefore, death also occurs at a younger age.
- They occur as a result of repeated, but not necessarily continuous exposure to carcinogens.
- There is usually a long latent interval between the time of first exposure and appearance of the tumour.
- This latent interval is usually of the order of 20 years or more.

The main diagnostic assessment remains a detailed occupational history of the cancer patient. The first job is to investigate whether the patient has been employed in a job which exposure to a carcinogen could occur. The worker is rarely aware of the chemical compound present in the occupational setting in which he is or was employed. The factory records may be helpful in this regard.

3.6 Control of Occupational Cancers
Once the causative agent of occupational cancer present in the work environment is identified, it can be very effectively controlled or even totally eradicated by various measures. The alert clinician, however, remains the most important source of leads to occupational cancer.

- The most effective measures to prevent occupational cancer are to prohibit the presence of carcinogenic substances in industrial processes. Only a few countries have legal restrictions. Industrial research on the use of no carcinogenic substances as substitutes should be developed.
- A second opinion is to eliminate the contact between workers and carcinogenic substances present in the workplace. This includes three aspects.
  - Production and transportation of carcinogens in closed systems.
  - Control of the working environment by monitoring levels of exposure and installation of air-conditioning systems effective even in emergencies.
• Personal protective equipment for those workers at a higher risk of coming into contact with carcinogenic substances.

• Workers participation in the prevention of an occupational cancer plays a very important role.
  • Health education programme reduces the delay in diagnosis in patients developing symptoms of disease by emphasising early working signs to be adopted.
  • Workers should be explained regarding the hazard of a cancer at a workplace.
  • Measures like housekeeping, ventilation, use of personal hygiene minimise the hazard.
  • They must be made aware of the early signs of cancer and seek medical advice at the earliest possible indication of any malignancy.
  • Personal habits like smoking are to be discouraged.

• In the light of the present knowledge, early detection and prompt treatment of early cancer and precancerous conditions provide the best possible protection for the workforce.

• Establishment of well equipped enterprise level occupational health centers manned by qualified and specifically trained medical personnel is essential for the industries handling hazardous chemicals.

• Periodical screening and medical surveillance of the workers for the early detection of probable cancer are useful.

• Early diagnostic tests like exfoliative cytology (Pap test), Radiography, Ultrasonography, Endoscopy, etc. have an important role. Immunological tests may be of some value, but are still at developmental stage, for example:
  • Galactosyl transferase II (GT II) isonzyme. This substance is present in the blood of the cancer patient long before the traditional symptoms appear.
  • Measurement of an anti-tumour immune factor. The response in the humoral Leucocyte adherence inhibition (H-LAI) may be caused by anti tumor antibodies of the IPG type in the serum.

3.7 Recent Development of Occupational Cancer in India

Following are some important developments which took place recently related with occupational cancer:

• The government of India have listed certain carcinogenic dye intermediates into prohibited substances and controlled substances under certain conditions and framed Model Rules in 1987 under Schedule XXIII of the Factories Act 1948.

• Handling of some of the carcinogenic chemicals like nickel, chromium, arsenic, cadmium, asbestos, benzene, etc are notified under section 87 of the Factories Act 1948 as ‘dangerous processes and operations’ requiring generally more stringent control measure.

• “Occupational cancer” has been included in the list of Notifiable Diseases (The third schedule under section 89 and 90 of the Factories Act 1948) during 1987 requiring factory mangers and medical practioners to report cases of occupational cancers also with a view to enable the state government to investigate such reported cases, to initiate adequate control measures and to enforce various safety and health provisions more effectively thereby safeguarding the health of the workers.

• The Directorate General Factory Advice Service and Labour Institutes propose a new schedule for the purpose of prevention and control of hazards caused by carcinogenic substances in use at work. Under this Schedule, prohibition, restriction and control of certain substances shall be included.

3.8 Control Measures

If a carcinogen is kept totally separate from the workforce through preventative measures such as a closed system then it can be safe. However, the reality is that leakages happen, as do fires and explosions. In addition, measures such as local exhaust ventilation and, in the case of dusts, dampening, are usually only going to be partially effective.

• The same applies to Personal Protective Equipment (PPE), which should only be used when all other control measures have been attempted and there is still residual risk.
PPE often fails, either because it is unsuitable, because it can be damaged, or simply because workers do not wear it at all times as it is uncomfortable, restrictive or doesn’t fit properly.

It is up to safety representatives to challenge the decisions their employers make to ensure that, whatever safeguards are in place, there is no exposure to cancer-causing substances in the workplace.

However, even with the most vigorous control measures, if cancer-causing substances are being used in the workplace then it can only be because there is no alternative and that all practical precautions are in place to ensure there is no exposure.

More importantly they have to ensure that the control measures that are in place are regularly monitored to ensure that they are effective.

### 3.9 List of Chemicals Causing Cancer

#### Appendix I

<table>
<thead>
<tr>
<th>Confirmed human carcinogens</th>
<th>Suspected human carcinogens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl chloride</td>
<td>Benzene</td>
</tr>
<tr>
<td>Bis (chloromethyl) ether</td>
<td>Carbon tetrachloride</td>
</tr>
<tr>
<td>Benzidine</td>
<td>Chloroform</td>
</tr>
<tr>
<td>Zinc chromates</td>
<td>Lead chromate</td>
</tr>
</tbody>
</table>

#### Appendix – II

(OSHA list of Carcinogenic substances)

<table>
<thead>
<tr>
<th>Asbestos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke Oven emission</td>
</tr>
<tr>
<td>Ethylene oxide</td>
</tr>
<tr>
<td>Benzidine</td>
</tr>
</tbody>
</table>

#### Appendix III

Indicative lists of carcinogenic substances and agents

(Drawn up by an ILO panel of consultants)

<table>
<thead>
<tr>
<th>Group 1 Exposure should be avoided</th>
<th>Group 2 Exposure should be limited through the application of stringent protective measures</th>
<th>Group 3 Exposure should be kept to a minimum through the use of the most feasible and application technical and personal protective measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 – Nitrodiphenyl</td>
<td>Propane soltone</td>
<td>Chemical Inorganic arsenic</td>
</tr>
<tr>
<td>Bis (Chloromethyl)ether</td>
<td>Asbestos</td>
<td>Nickel Carbonyl</td>
</tr>
<tr>
<td>Methylinotrosur</td>
<td>Vinyl chloride</td>
<td>Dimethyl sulphate</td>
</tr>
<tr>
<td>4 – Aminodiphenyl</td>
<td>Benzene</td>
<td>Ethylenimine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coal pitch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haematite mining</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industrial processes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treatment of chromium ore</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Treatment of nickel ores</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haematite mining</td>
</tr>
</tbody>
</table>
3.10 Toxicity of Dangerous Chemicals (Pesticides)

For all pesticides to be effective against the pests they are intended to control, they must be biologically active, or toxic. Because pesticides are toxic, they are also potentially hazardous to humans, animals, other organisms, and the environment. Therefore, people who use pesticides or regularly come in contact with them must understand the relative toxicity, potential health effects, and preventative measures to reduce exposure to the products they use.

Pesticide toxicity and exposure

- Hazard, or risk, of using pesticides is the potential for injury, or the degree of danger involved in using a pesticide under a given set of conditions. Hazard depends on the toxicity of the pesticide and the amount of exposure to the pesticide and is often illustrated with the following equation:
  \[
  \text{Hazard} = \text{Toxicity} \times \text{Exposure}
  \]

- The toxicity of a pesticide is a measure of its capacity or ability to cause injury or illness. The toxicity of a particular pesticide is determined by subjecting test animals to varying dosages of the active ingredient and each of its formulated products. The active ingredient is the chemical component in the pesticide product that controls the pest.

- By understanding the difference in toxicity levels of pesticides, a user can minimize the potential hazard by selecting the pesticide with the lowest toxicity that will control the pest.

- Applicators may have little or no control over the availability of low toxicity products or the toxicity of specific formulated products. However, applicators can minimize or nearly eliminate exposure and thus reduce hazard by following the label instructions, using personal protective clothing and equipment (PPE), and handling the pesticide properly. For example, more than 95 percent of all pesticide exposures come from dermal exposure, primarily to the hands and forearms. By wearing a pair of unlined, chemical-resistant gloves, this type of exposure can be nearly eliminated.

3.10.1 Acute Toxicity and Chronic Toxicity and its Effects

- Acute toxicity of a pesticide refers to the chemical’s ability to cause injury to a person or animal from a single exposure, generally of short duration. The harmful effects that occur from a single exposure by any route of entry are termed “acute effects.” The four routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and the eyes.

- The chronic toxicity of a pesticide is determined by subjecting test animals to long-term exposure to the active ingredient. Any harmful effects that occur from small doses repeated over a period of time are termed “chronic effects.” Suspected chronic effects from exposure to certain pesticides include birth defects, toxicity to a fetus, and production of benign or malignant tumors, genetic changes, blood disorders, nerve disorders, endocrine disruption, and reproduction effects.

- The chronic toxicity of a pesticide is more difficult than acute toxicity to determine through laboratory analysis.

3.11 Symptoms of Pesticide Poisoning

The symptoms of pesticide poisoning can range from a mild skin irritation to coma or even death. Different classes or families of chemicals cause different types of symptoms. Individuals also vary in their sensitivity to different levels of these chemicals. Some people may show no reaction to an exposure that may cause severe illness in others. Because of potential health concerns, pesticide users and handlers must recognize the common signs and symptoms of pesticide poisoning. The effects, or symptoms, of pesticide poisoning can be broadly defined as topical and systemic.
Topical effects generally develop at the site of pesticide contact. These are result of either the pesticide’s irritant properties (either the active and/or inert ingredient) or an allergic response by the victim.

Systemic effects often occur away from the original point of contact as a result of the pesticide being absorbed into and distributed through out the body.

<table>
<thead>
<tr>
<th>Topical effects</th>
<th>Systemic effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topical effects reported effects are dermatitis (reddening of the skin to rashes and/or blisters), or inflammation of the skin</td>
<td>Most commonly includes nausea, vomiting, fatigue, headache, and intestinal disorders</td>
</tr>
<tr>
<td>Symptoms: cough, wheeze, or sneeze when exposed to pesticide sprays eyes, mucous membranes of the nose, and even the sensitive linings of the mouth and back of the throat feel raw and scratchy till the person is in contact of that chemical hypersensitivity or allergic reaction including reddening and itching of the eyes and skin to respiratory discomfort often resembling an asthmatic condition</td>
<td>Symptoms: In advanced poisoning cases, the individual may experience changes in heart rate, difficulty breathing, convulsions, and coma, which could lead to death.</td>
</tr>
</tbody>
</table>

Table 3.2 Effects of pesticide poisoning

Exposure and preventative measures
The hazard or risk involved with using a pesticide depends on both the toxicity of the product and the amount of exposure to the product (Hazard = Toxicity x Exposure). Preferably, use of low-toxicity product is recommended when possible, but even they can be harmful if your exposure level is high. However, regardless of the product’s toxicity, if the exposure level is low, then the hazard will also be low. To reduce the possibility of exposure and to protect your health, always wear the personal protective equipment (PPE) as indicated on the product label. The following are general PPE guidelines to protect against the four routes of entry:

**Dermal**
- More than 95 percent of all exposures are dermal. Dermal absorption may occur as the result of a splash, spill, or drift or when cleaning or repairing equipment.
- Wear unlined, chemical resistant gloves to eliminate most dermal exposures.
- Minimum dermal protection for most pesticides consists of a long-sleeved shirt, long trousers, gloves, and proper footwear.
- For extra precaution, consider wearing coveralls, a waterproof hat, and unlined rubber boots.
- Additionally, wearing a liquid proof apron or rain suit is recommended when mixing and pouring concentrates or when using highly toxic products.

**Inhalation**
- For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system.
- Respiratory protection is especially important when pesticide powders, dusts, gases, vapors, or small spray droplets can be inhaled.
- Use the respirator as designed for its intended use, and always follow the manufacturer’s instructions.
- Select only equipment approved by the National Institute of Occupational Safety and Health (NIOSH) and the Mine Safety and Health Administration (MSHA).
Oral
- Accidental oral exposure most frequently occurs when pesticides have been taken from the original container and put into an unlabeled bottle or food container.
- Unfortunately, children are the most common victims in these situations. Store pesticides only in their original containers, and keep the original label attached to the container. Store pesticides only in their original containers and keep the original label attached to the container.
- Never use your mouth to clear a spray line or to siphon a pesticide from a tank or container.
- After handling or working with pesticides, wash your hands and face thoroughly with soap and water before eating, drinking, or smoking.

Eyes
- Eyes are very sensitive to many pesticides and, considering their size, are able to absorb large amounts of chemical.
- Serious eye exposure can result from a splash, spill, or drift or by rubbing the eyes with contaminated hands or clothing.
- Tight-fitting chemical splash goggles or a full-face shield should be worn if there is any chance of getting pesticides in the eyes, especially when pouring or mixing concentrates and handling dusts.
- When pouring from a container, keep the container below eye level to avoid splashing or spilling chemicals on your face or protective clothing.

Some major pesticides are given below:

<table>
<thead>
<tr>
<th>Dimethoate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>White paper with camphor like odour</td>
</tr>
<tr>
<td><strong>Use:</strong></td>
<td>Insecticides</td>
</tr>
<tr>
<td><strong>Chemical group:</strong></td>
<td>Organo phosphorus compound</td>
</tr>
<tr>
<td><strong>Common formulation:</strong></td>
<td>Emulsion concentration water dispersible power, granules, technical compound and other formulations as per the requirement.</td>
</tr>
<tr>
<td><strong>Toxicity-Threshold limit:</strong></td>
<td>0.1 mg / m³</td>
</tr>
<tr>
<td><strong>Absorption Route:</strong></td>
<td>It is readily absorbed by gastrointestinal tract and to a lesser extent through the intact skin and by inhalation.</td>
</tr>
<tr>
<td><strong>Pathology:</strong></td>
<td>It is an insecticides acaridide of moderate mammalian toxicity. It is active after metabolism both as a contact and as a systematic insecticide. It is bio transformed in the liver microsomes by a conversion into its oxygen analogue, which is the active form.</td>
</tr>
<tr>
<td><strong>Dangerous doses:</strong></td>
<td>Oral LD of dimethoate to humans is above 30 mg / kg⁵⁰</td>
</tr>
<tr>
<td><strong>Signs and symptoms:</strong></td>
<td>Early symptom of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, stomach pains, blurred vision, slurred speech and muscle twitching, later there may be convulsions, coma, loss of reflexes and loss of sphincter contra.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dichlorvos</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>It is oily, colourless to amber liquid with an aromatic odour.</td>
</tr>
<tr>
<td><strong>Use:</strong></td>
<td>Insecticides</td>
</tr>
<tr>
<td><strong>Chemical group:</strong></td>
<td>Organophosphorus compound. Hazardous decomposition: Toxic chloride fumes and phosgene formed if heated to decomposition or a contact with acid or acid fumes.</td>
</tr>
</tbody>
</table>
**Industrial Hygiene and Occupational Health**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Common formulation:</th>
<th>Toxicity-Threshold limit:</th>
<th>Absorption Route:</th>
<th>Dangerous:</th>
<th>Signs and symptoms:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorodone</td>
<td>Emulsifiable concentrations, oil solutions and other formulation as per the requirement.</td>
<td>1 mg / m³</td>
<td>It is absorbed by inhalation, gastrointestinal tract and contact skin.</td>
<td>Toxic changes are typical or organophosphosphate insecticides poisoning with progression respiratory distress, respiratory paralysis and death if there is no clinical intervention. Early symptoms of poisoning may include sweating, salivation, lacrimation, nausea, vomiting, abdominal cramps, diarrhea, later involuntary defecation and urination, slurred speech, coma, apnea and death.</td>
<td></td>
</tr>
<tr>
<td>Chlorodone</td>
<td>Emulsifiable concentrations, kerosene solutions, dust and oil solution and other formulation as per the requirement.</td>
<td>0.5 mg / m³</td>
<td>It is absorbed by inhalation, gastrointestinal tract and intact skin.</td>
<td>Pathology: It is persistent organochlorine insecticides of moderate toxicity that may be stored in body fats. It causes stimulation of the central nervous system. It has a cumulative effect on the liver, initially causing liver enlargement and microsomal enzyme induction and eventually causing liver damage and bile duct proliferation. Damage to the optic nerve has been reported in animals.</td>
<td></td>
</tr>
<tr>
<td>Endosulfan</td>
<td>Wettable powder, granules, emulsifiable concentrates, dusts and ultra low volume (ULV) formulation and other formulations as per the requirements.</td>
<td>0.1 mg / m³</td>
<td>It is absorbed by inhalation, gastrointestinal tract and intact skin.</td>
<td>Signs and symptoms: Early symptoms of poisoning may include apprehension and agitation, abdominal pain, vomiting and blood coughing hoarseness, blurred vision, noisy respiration, incoherent speech and irritational behaviour, muscle twitching can also occur.</td>
<td></td>
</tr>
<tr>
<td><strong>Endosulfan</strong></td>
<td><strong>Description:</strong> It is brown crystalline flakes with a terpene odour.</td>
<td><strong>Use:</strong> Insecticides.</td>
<td><strong>Chemical group:</strong> Organochlorine compound.</td>
<td><strong>Common formulation:</strong> Wettability powder, granules, emulsifiable concentrates, dusts and ultra low volume (ULV) formulation and other formulations as per the requirements.</td>
<td><strong>Pathology:</strong> It is between moderate and highly toxic. It is readily metabolised and excreted and dose not accumulates in the body.</td>
</tr>
<tr>
<td><strong>Endosulfan</strong></td>
<td><strong>Chemical property</strong> It is sensitive to moisture, acids, and alkali. It will undergo slow hydrolyses producing sulphur dioxide (SO₂), endosulfanm, alcohol via the intermediate endosulfan sulphate.</td>
<td><strong>Dangerous:</strong> Lethal oral doses in human in between 50 and 500 mg/ kg.</td>
<td><strong>Signs and symptoms:</strong> On acute intoxication neurological manifestations may occur such as irritability, restlessness, muscular twitching and convulsion. Lung oedema and cyanosis may precede death.</td>
<td><strong>Pathology:</strong> It is between moderate and highly toxic. It is readily metabolised and excreted and dose not accumulates in the body.</td>
<td><strong>Chemical property</strong> It is sensitive to moisture, acids, and alkali. It will undergo slow hydrolyses producing sulphur dioxide (SO₂), endosulfanm, alcohol via the intermediate endosulfan sulphate.</td>
</tr>
</tbody>
</table>
### Aldrin

**Description:** Crystals: White, odourless; Solid: dark brown, odourless

**Use:** Insecticides

**Chemical group:** Organochlorine compound

**Common formulation:** Emulsifiable concentrates, wettable powders, granules and other formulation as per the requirement.

**Toxicity-Threshold limit:** 0.25 mg / m$^3$

**Absorption Route:** It is absorbed by inhalation, gastrointestinal tract and intact skin. Organic solvents such as sylene and edible and other vegetable oils enhance the rate of absorption of the toxicant into the body.

**Signs and symptoms:** Early symptoms of poisoning are headache, dizziness, nausea, vomiting, loss of appetite, general malaise and possibly insomnia. Later convulsion may occur.

**Pathology:** Aldrin is an organochlorine pesticide of high mammalian toxicity. It is an essential nervous system stimulant produce convulsions. After absorption it is rapidly deoxidised to dialdrin and it is stored in body tissues, particularly body fats and is slowly excreted. It is mainly excreted as hydrophilic metabolites are also excreted in the urine.

**Chemical property**

 опасно

**Dangerous** Persons exposed to oral doses which exceed 10 mg/kg body weight frequently become acutely ill. The lethal dose of aldrin for an adult is estimated to be about 5g.

### Warfarin

**Description:** Colourless, tasteless and odourless crystals.

**Use:** Rodenticide.

**Chemical group:** Hydroxycoumarin compound.

**Common formulation:** Powdered concentrates, dust and other formulations as per the requirement.

**Toxicity-Threshold limit:** 0.1 mg/m$^3$

**Absorption Route:** Absorbed from the gastrointestinal tract, inhalation and to a much lesser extent through the intact skin.

**Signs and symptoms:** On repeated exposure symptoms may occur from the sixth or seventh day and include back and abdominal pain followed by vomiting, nose and gum bleeding, massive bruising and haematoma formation.

**Pathology:** It is highly toxic to mammals on repeated ingestion. It is an anticoagulant rodenticide, it inhibits the formation of prothrombin by replacing vitamin K and so reduce the clotting capacity of blood. It also increases capillary permeability. It does not accumulate to any extent in body tissues. It is metabolised by liver and is excreted through urine and faces.

**Chemical property**

 опасно

**Dangerous** 1 -2 mg / kg for has caused serious illness and death in man.

---

**Table 3.3 Major pesticides**
3.12 General Precautions

In nearly all poisoning cases due to pesticides, careless handling or improper storage was the cause of the poisoning.

What to do for pesticide poisoning?

Poison on the skin

- The faster the poison is washed off the patient, the less injury will result.
- Remove clothing.
- Drench skin with water (shower, hose, faucet, and pond).
- Cleanse skin and hair thoroughly with liquid detergent and water. (Detergents and commercial cleansers are better than soap.)
- Dry and wrap the victim in a blanket.

WARNING: If at all possible, do not allow any pesticide to get on you while you are helping the victim.

Chemical burns of the skin

- Remove contaminated clothing.
- Wash with large quantities of running water.
- Immediately cover loosely with a clean, soft cloth.
- Avoid use of ointments, greases, powders and other drugs in first aid treatment of burns.

Pesticides in the eye

- It is most important to wash the eye out as quickly, but as gently, as possible.
- Hold eyelids open and wash eyes with a gentle stream of clean running water. Continue washing for 15 minutes or more.
- Do not use chemicals or drugs in wash water. They may increase the extent of the injury.

Inhaled poisons (Dusts, Vapors, Gases)

- If the victim is in an enclosed space, do not go in after them without an air-supplied respirator.
- Carry patient (do not let them walk) to fresh air immediately. Open all doors and windows.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular. If the heart has stopped, perform cardio-pulmonary resuscitation.
- Keep patient as quiet as possible.
- If patient is convulsing, watch their breathing and protect them from falling and striking their head. Keep their chin up so their air passage will remain free for breathing.
- Prevent chilling (wrap patient in blankets, but don’t overheat).
- Do not give alcohol in any form.

Swallowed poisons

- Poison Control and medical personnel do not recommend inducing vomiting.
- Usually the label will advise you in the First Aid Statement or Statement of Practical Treatment whether a person who has swallowed pesticide should be made to vomit.
General symptoms which might indicate pesticide poisoning are given below:

<table>
<thead>
<tr>
<th>Mild poisoning</th>
<th>Moderate poisoning</th>
<th>Severe poisoning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any mild symptoms plus any of:</td>
<td>Any mild or moderate symptoms plus any of:</td>
</tr>
<tr>
<td>dizziness</td>
<td>abdominal cramps</td>
<td>inability to breathe</td>
</tr>
<tr>
<td>weakness</td>
<td>vomiting</td>
<td>chemical burns on skin</td>
</tr>
<tr>
<td>fatigue</td>
<td>diarrhea</td>
<td>respiratory distress</td>
</tr>
<tr>
<td>nervousness</td>
<td>excessive salivation</td>
<td>loss of reflexes</td>
</tr>
<tr>
<td>loss of appetite</td>
<td>constriction in throat and chest</td>
<td>uncontrollable muscle twitching</td>
</tr>
<tr>
<td>thirst</td>
<td>abdominal cramps</td>
<td>unconsciousness</td>
</tr>
<tr>
<td>nausea</td>
<td>rapid or slow pulse</td>
<td>convulsions</td>
</tr>
<tr>
<td>irritation of throat and nose</td>
<td>excessive perspiration</td>
<td></td>
</tr>
<tr>
<td>eye irritation</td>
<td>trembling</td>
<td></td>
</tr>
<tr>
<td>constriction of pupils</td>
<td>muscle incoordination</td>
<td></td>
</tr>
<tr>
<td>blurred vision</td>
<td>mental confusion</td>
<td></td>
</tr>
<tr>
<td>skin irritation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>changes in mood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>loss of weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>headache</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4 General symptoms of pesticide poisoning

3.13 Transportation of Pesticides

Once you purchase a pesticide, you are responsible for its safe transportation. Accidents can occur when transporting pesticides even a short distance. Careless transportation can result in broken containers and spills that might contaminate the environment or cause personal injury. Know how to prevent transportation problems, and be prepared for an emergency.

Transportation

- Vehicles must be in safe operating condition.
- The back of an open pickup truck is the best mode.
- Vans, minivans, and station wagons, although less than ideal, may be used if the windows are left open to prevent vapour accumulation.
- Pesticides should not be transported in compact or mid-size automobiles except as a last resort. If a car must be used, place the containers in the trunk and make certain that both the trunk and passenger space are well ventilated; i.e., leave the trunk lid ajar and open the windows.
- Travel at a reduced speed and, when necessary, use slow moving-vehicle emblems.

Never

- transport pesticides in the passenger space of a closed vehicle;
- allow passengers or pets to ride with the pesticides;
- Leave an unsecured vehicle unattended if it contains pesticides.
**Loading and unloading**

- Inspect each container before loading, and confirm that
- labels are attached and legible;
- all caps are tightly closed and properly sealed;
- the outside is not contaminated with pesticide;
- a current Material Safety Data Sheet (MSDS) accompanies each pesticide.
- Always transport pesticides in their original, labeled containers.
- Avoid carrying glass containers; if there is no alternative; wrap them in foam packing materials to prevent breakage.
- Protect pesticide bags from punctures, tears, and moisture during transport.
- Secure all pesticide containers to prevent rolling and sliding.
- Avoid transporting fertilizer, seed, feed, drugs, clothing, and foodstuffs with pesticides.
- Transfer pesticide containers to an appropriate storage facility immediately upon reaching your destination.

### 3.14 Safety Tips for the Storage Area

- Always store pesticides in their original containers with the original label attached.
- However, if a pesticide container is leaking, transfer the chemical to a sturdy new container that can be sealed.
- Attach the original label to the new container, or label the new container with specific information immediately.
- Purchase only the quantities of pesticides required for a single season to minimize the need for off-season storage.
- Keep the storage site neat and tidy. Pesticide handlers must be able to
  - see pesticide labels;
  - detect leakage or corrosion;
  - get to leaks or spills to clean them up.
- Store protective equipment and clothing in a nearby location that provides immediate access but is away from pesticides and their fumes, dusts, or possible spills.
- Provide an immediate supply of clean water, and have an eyewash dispenser immediately available for emergencies.
- Soap and a first aid kit are also necessary.
- Establish procedures to control, contain, and clean up spills. Familiarize everyone with the procedures.
- Provide tools (shovel, broom, and dustpan) and absorbent materials (clay, sawdust, shredded paper) to clean up spills.
- Mark pesticide containers with the date of purchase and rotate inventory to ensure that the oldest material is used first.
- Maintain an inventory of all safety kits and signs.
- Develop a fire emergency plan in consultation with the local emergency planning committee and fire, police, and sheriff’s departments.
- Notify the appropriate officials of the types of pesticides and quantities stored.
- Know and follow local fire codes. Consult with local fire authorities regarding the best methods for fire protection.
Summary

- The appearance of cancers in workers exposed to certain physical and chemical agents is one of the most dramatic features of occupational pathology.
- For many toxic chemicals, the respiratory (breathing) system is the quickest and most direct route of entry into the circulatory system.
- The hazard or risk involved with using a pesticide depends on both the toxicity of the product and the amount of exposure to the product (Hazard = Toxicity x Exposure).
- Reading warning labels and Material Safety Data Sheets (MSDS) is very important whenever one comes with the contact of any substance.
- Acute toxicity of a pesticide refers to the chemical’s ability to cause injury to a person or animal from a single exposure, generally of short duration. The harmful effects that occur from a single exposure by any route of entry are termed “acute effects.” The four routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and the eyes.

References


Recommended Reading

Self Assessment

1. The appearance of cancers in workers exposed to certain physical and chemical agents is one of the most dramatic features of _______ pathology.
   a. Occupational
   b. Functional
   c. Social
   d. Personal

2. At an workplace, the primary route of exposure to a carcinogenic agent is through ________.
   a. skin
   b. inhalation
   c. respiratory systems
   d. eyes

3. A worker must be warned about a hazard to become aware of the need to wear _______ protection.
   a. respirator
   b. eye
   c. head
   d. skin

4. The most effective measures to prevent occupational cancer are to prohibit the presence of ________ substances in industrial processes.
   a. Asbestos
   b. Dust
   c. Carcinogenic
   d. Pesticide

5. Which of the following equation illustrates hazard?
   a. Hazard = Toxicity / Exposure
   b. Exposure = Toxicity x Hazard
   c. Hazard = Toxicity x Exposure
   d. Toxicity = Hazard x Exposure

6. The ________ of a pesticide is a measure of its capacity or ability to cause injury or illness.
   a. amount
   b. intensity
   c. measurement
   d. toxicity

7. The harmful effects that occur from a single exposure by any route of entry are termed ____________.
   a. acute effects
   b. side effects
   c. hazards
   d. professional hazards
8. Careless transportation of __________ can result in broken containers and spills that might contaminate the environment or cause personal injury.
   a. pesticides
   b. chemicals
   c. medicines
   d. asbestos

9. One should mark pesticide containers with __________ and rotate inventory to ensure that the oldest material is used first.
   a. red colour
   b. words “danger”
   c. words “inflammable”
   d. date of purchase

10. ____________ of a pesticide refers to the chemical’s ability to cause injury to a person or animal from a single exposure, generally of short duration.
    a. Acute toxicity
    b. Acute effects
    c. Side effects
    d. Hazards
Chapter IV
Accident Prevention (Agents Causing Injury and Death)

Aim
The aim of this chapter is to:

- define industrial management’s responsibilities
- explain present position and scope for improvement
- evaluation of injuries and compensation

Objectives
The objectives of this chapter are to:

- describe accident theories
- explain accident prevention techniques
- define disablements

Learning outcomes
At the end of this chapter, you will be able to:

- discuss the role of management
- explain provisional causes of accidents
- elaborate on amount of compensation
4.1 Introduction
With rapid advances in industrial processes, newer types of dangers to life, limb and health are being increasingly introduced. The broad category of industrial accidents covers anything from small cuts and bruises to huge disasters that affect a large population of people. Mechanical, electrical, chemical and radiation hazards are set up on all sides. Yearly, several lacks of employees are injured in factories due to accidents. These accidents represent a social loss of great magnitude in the form of pain, loss of hearing capacity and cost due to disturbance to economic efficiency. The pain and suffering of the injured as well as the emotional loss to the victims of the sufferers and accidents causing permanent disfigurements of disabilities are impossible to be summed up or evaluated.

4.2 Industrial Management’s Responsibilities
The function of industry as a whole is different from the sum total of many persons’ search for a livelihood. It is the production of goods and services which society requires with a minimum waste of resources. In this larger context, it is important that production or productivity should not be regarded as an end itself but as a means of obtaining the supply of goods and services, income and leisure, in order that all people can improve their standard of living and enjoy the benefits; and with these results can bring more satisfactory life. While achieving this, if the path becomes overwhelmed with casualties, where people are killed, mentally or physically or are allowed to suffer in other ways from injuries, it indicates failure on the part of the industrial management to discharge its prime social responsibility. Industrial management’s prime duty to the inhabitants is that it should not waste the most valuable resource i.e. humans. Besides, the heavy cost due to accidents is waste, which in these days of ruthless competition, we can ill afford. Like other forms of waste, it is serious reflection on the standard of overall efficiency of those organisations where the accident rate persists at a high level.

4.3 Provisional Causes of Accidents
Following are the reasons of the state of accidents in India as compared to UK and USA.
- More manual operations in production processes.
- Insufficient voluntary efforts on the part of management, trade unions and others.
- The lower economic and educational status of workers.
- Low wages and compensation rates.
- Tendency to believe that accidents are inevitable.
- Management being not sufficiently conscious of the high cost of accident, they are often attributed to poor performance.

However, experience indicates that remarkable success in accident prevention can be achieved even with the existing disadvantages, by planned efforts in individual plant. This is borne out by the spectacular reduction in the factories which have tackled this problem in a scientific manner.

4.4 Accident Theories
An accident may be defined as an unplanned, uncontrolled and undesirable incident, which may or may not result in an injury from this definition. It could be said that injuries are always the results of an accident. The injuries may result in partial or permanent disability and may even cause fatality. Some of the theories that are evolved about the trend of accidents are as follows:

Pure chance theory:
Under this theory, an accident was considered to be an Act of God. Workers were made to believe this theory and nothing was initiated to prevent the accidents, as it was said that the accidents cannot be controlled.

Biased liability theory:
This theory says that once a person sustains injury, the chances of his getting injured again are either decreased or increased. If the probability has increased the theory is known as “Contagious hypothesis” and if the probability is decreased it is called “Burned finger hypothesis”
**Accident proneness:**
This theory says that there are certain people who are injured more than others. However, the accident data does not lend any support to this concept. It may be said that people are trying to take advantage of this concept in order to evade steps for accident prevention.

**Adjustment stress theory:**
This theory says that people who fail to reach some sort of adjustment with working environment may have more accidents than others.

**Domino’s theory:**
This theory is evolved by Mr. Heinrich, who had investigated a number of accidents. He came to the conclusion that there is sequence of factors before an injury takes place (the factors were shown in the form of a Domino) and if any of the preceding factors is controlled, injuries do not take place. Mr. Heinrich had shown the factors in the form of the Domino Ancestors or social environment fault of persons Unsafe Acts / Unsafe conditions-Accident-Injury.

**Multiple causation theory:**
This theory says that any contributing factors causes and sub causes combine together in a random fashion causing accidents. According to this theory an accident occurs due to many undesirable conditions and the identification and removal of all these would lead to prevention of reoccurrence of all similar accidents.

Consequences of an accident are damage. Damage can occur to person or matter. In the first case, we call it an injury and in the later case it is called property loss. In a complex system of work area the final result would be damage to property and/or injury to the person.

### 4.5 Accident Prevention Techniques
Accident prevention has been traditionally based on learning from accidents and near accidents (near misses). By investigating every incident, management can learn about causes and can take actions towards removing the causes. No safety programme would be effective without involvement of all concerned i.e. management, supervisors and the workers. Hence, apart from the interest taken by the management, workers are to be motivated to adopt the safe system of work. Accidents also could be understood as the result of ‘Danger’ acting on an ‘Object’. The object may be a man, machine, material. Hence to prevent an accident we should stop the danger from acting and/or stop the action of danger before it damages the object. This can be achieved by:

- Completely eliminate the danger from the process by identifying them in the planning stage itself.
- Past experience in a similar process or the result from a stimulation of the system is used for identifying the danger.
- Identify and eliminate high-risk activities
- Design jobs with current and anticipated workers in mind
- Tailor safety-training programs to employees
- Empower employees to engage in accident prevention and job design
- Treat accidents as performance errors
- Establish behaviour-based safety-management programs
- Train supervisors in confrontation-management skills
- Change mundane routines
- Empower employees to be responsible for their equipment
- Establish an ergonomic approach to workplace design
- Develop training programs based on behaviour modelling
- Develop programs to eliminate workplace illiteracy
### 4.6 Causes of Industrial Accidents

The causes of industrial accidents can occur in the environment around the workplace or within the work environment. External causes of industrial accidents may include fires, chemical spills, toxic gas emission or radiation. The causes of industrial accidents in these cases might include organisational errors, human factors, abnormal operational conditions, natural forces, software or component failures, and outside interference. Internal causes of industrial accidents can involve equipment or other work related tangibles, harmful materials, toxic chemicals, and human error. Causes of industrial accidents can be broken down into two broad categories: unsafe conditions and unsafe acts.

<table>
<thead>
<tr>
<th>Unsafe conditions</th>
<th>Unsafe acts</th>
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<tbody>
<tr>
<td>Includes:</td>
<td>Includes:</td>
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<tr>
<td>• insufficient workspace lighting,</td>
<td>• Actions or failures to act which result in injury.</td>
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<tr>
<td>• excessive noise,</td>
<td>• This can be a result of employee negligence but</td>
</tr>
<tr>
<td>• slippery or unsafe flooring,</td>
<td>employers, organisations, and product manufacturers</td>
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<td>• extreme temperature exposure,</td>
<td>can also be liable for the causes of industrial</td>
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<td>• inadequate protection when working with</td>
<td>accidents.</td>
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<td>machinery or hazardous materials,</td>
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<td>• unstable structures,</td>
<td></td>
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<td>• electrical problems,</td>
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<tr>
<td>• machine malfunction or failure, and more</td>
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</tbody>
</table>

Table 4.1 Causes of industrial accidents

### 4.7 Types of Analyses

There are five primary types of analyses of accidents, each having a distinct purpose:

- Analyses and identification of where and which types of accidents occur. The goal is to determine the incidence of the injuries, as associated, for example, with sectors, trade groups, enterprises, work processes and types of technology.
- Analyses with respect to monitoring developments in the incidence of accidents. The purpose is to be warned of changes, both positive and negative. Measuring the effect of preventive initiatives may be the result of such analyses, and increases in new types of accidents within a specified area will constitute warning of new risk elements.
- Analyses to prioritise initiatives that call for high degrees of risk measurement, which in turn involve calculating the frequency and seriousness of accidents. The goal is to establish a basis for prioritisation to determine where it is more important to carry out preventive measures than elsewhere.
- Analyses to determine how the accidents occurred and, especially, to establish both direct and underlying causes. This information is then applied to the selection, elaboration and implementation of concrete corrective action and preventive initiatives.
- Analyses for elucidation of special areas which have otherwise attracted attention (a sort of rediscovery or control analyses). Examples include analyses of incidences of a special injury risk or the discovery of a hitherto unrecognised risk identified in the course of examining an already known risk.

These types of analyses can be carried out at several different levels, ranging from the individual enterprise to the national level. Analyses at several levels will be necessary for preventive measures. Analyses involving general accident incident rates, monitoring, warning and prioritisation will be carried out chiefly at higher levels, whereas analyses describing direct and underlying accident causes will be conducted at lower levels. The results of the analyses will accordingly be more specific at the individual level and more general at the higher level.
4.8 Evaluation of Injuries and Compensation

Evaluation of industrial injuries is done for the purpose of assessing the compensation to the affected worker. For this purpose, there’s a comprehensive act known as “Workmen’s Compensation Act.” This act is not interested merely in physical disability because compensation cannot be paid for any physical disability unless there is loss of earning capacity. The loss of earning capacity is proportional to the loss of function of the affected part of the body. Industrial injury or accident means any organic injury of functional disturbance whether immediate or subsequent, or death, occurring suddenly in the course of the employment or in consequence thereof, irrespective of the place or time where it occurs.

The consequence of any of the aforesaid injuries may be:

- Temporary incapacity
- Permanent partial incapacity
- Permanent total incapacity
- Death

4.8.1 Main Features of Compensation

The main features of the compensation are:

- Payment of compensation has been made obligatory on all employers whose employees are entitled to claim benefit under the Workman’s Compensation Act.
- The workman or his dependants can claim compensation if the injury has been caused by accident arising out of and in the course of employment. If the accident does not result in death then the accident must not be due to the workman being under the influence of drinks or drugs at the time of the accident; or the accident is not caused due to the disobedience of the workman of rules or disregard of safety devices.
- The amount of compensation payable depends in case of death on the average monthly wages of the deceased workman and in the case of an injured workman both on the average monthly wages and the nature of disablement.

The liability of the employer to pay compensation is dependant upon the following four conditions:

- Personal injury must have been caused to a workman
- Such injury must have been caused by an accident
- The accident must have arisen out of and in the course of employment
- The injury must have resulted either in death of the workman or his total or partial disablement for a period exceeding three days.

4.9 Disablements

- **Partial disablement**: Partial disablement is of two kinds:
  - **Temporary or partial disablement**: If the earning capacity of the workman is reduced in relation to the employment, in which he had been at the time of the accident resulting in such disablement, it is temporary partial disablement.
  - **Permanent partial disablement**: If the injury caused by the accident results in the reduction of the earning capacity in respect of employment, which the workman was capable of undertaking at the time of the accident, it is permanent partial disablement.

- **Total disablement**: When a workman is incapacitated of doing any work, which he was capable of performing at the time of the accident resulting in such disablement, it is total disablement.

For claiming compensation there must be injury due to an accident arising out of and in the course of employment. The expression “accident” has not been defined in the Act. But it means an unexpected event, which is not anticipated. Such accident must have taken place out of and in the course of employment.
4.10 Amount of Compensation

The amount of compensation shall be as follows:

- **Where death results from the injury:** an amount equal to fifty percent of the monthly wages of the deceased workman multiplied by the relevant factor.
- **Where permanent total disablement results from the injury:** an amount equal to sixty percent of the monthly wages of the injured workman multiplied by the relevant factor.
- **Where temporary disablements whether total or partial results from the injury:** a half monthly payment of the sum equivalent to twenty five percent of monthly wages of the workman to be paid.

Compensation will be paid when it becomes due. If there is a dispute regarding amount of compensation claimed by a workman, but no dispute about the liability, the employer shall either provisionally pay the amount acceptable to him to the workman or deposit the amount with the Commissioner. The workman may accept the amount paid by the employer and may make further claim for the additional amount.

4.11 Medical Examination

- A workman, who is injured and has given notice of an accident to the employer, shall submit himself for medical examination by the employer.
- Any such offer made by the employer must be free of charge and made within three days of service of notice to the employer.
- If a workman refuses to submit himself for examination by a qualified medical practitioner as required either by the employer or the commissioner, his right to compensation shall be suspended for the period of refusal or obstruction.
- The examination has to take place within seventy-two hours after the workman has offered himself for medical examination.
- Where a workman whose right to compensation has been suspended, dies without having submitted himself for medical examination as required, the Commissioner may, if he thinks fit, direct the payment of the compensation to the dependants of the deceased workman.
- The workman shall be at liberty to claim compensation from the principal for whose trade or business he was employed for by the contractor. The question as to the right to indemnity and also amount of indemnity shall if there is no agreement between the parties regarding this, be settled by the Commissioner.
Summary

- It is important that production or productivity should not be regarded as an end itself but as a means of obtaining the supply of goods and services, income and leisure, in order that all people can improve their standard of living and enjoy the benefits.

- An accident may be defined as an unplanned, uncontrolled and undesirable incident, which may or may not result in an injury.

- By investigating every incident, management can learn about causes and can take actions towards removing the causes.

- Payment of compensation has been made obligatory on all employers whose employees are entitled to claim benefit under the Workman’s Compensation Act.

- The amount of compensation payable depends in case of death on the average monthly wages of the deceased workman and in the case of an injured workman both on the average monthly wages and the nature of disablement.

References


Recommended Reading


Self Assessment

1. With rapid advances in __________ processes, newer types of dangers to life, limb and health are being increasingly introduced.
   a. industrial
   b. social
   c. public
   d. production

2. Which of the following statements is true?
   a. Industrial management’s prime duty to the inhabitants is that it should not waste the most valuable resource i.e. capital.
   b. Industrial management’s prime duty to the inhabitants is that it should not waste the most valuable resource i.e. land.
   c. Industrial management’s prime duty to the inhabitants is that it should not waste the most valuable resource i.e. humans.
   d. Industrial management’s prime duty to the inhabitants is that it should not waste the most valuable resource i.e. labour.

3. Which of the following statements is true?
   a. It could be said that accidents are always the results of an injury.
   b. It could be said that injuries are always the results of a precaution.
   c. It could be said that precautions are always the results of an accident.
   d. It could be said that injuries are always the results of an accident.

4. Under _______ theory, an accident was considered to be an Act of God.
   a. Adjustment
   b. Pure chance
   c. Domino’s
   d. Multiple causation

5. _______ causes of industrial accidents can involve equipment or other work related tangibles, harmful materials, toxic chemicals, and human error.
   a. Internal
   b. External
   c. Hazardous
   d. Permanent

6. Causes of industrial accidents can be broken down into two broad categories, namely, ________________.
   a. safe conditions and unsafe precautions
   b. unsafe conditions and unsafe acts
   c. safe precautions and unsafe surrounding
   d. unsafe instruments and unsafe surrounding
7. Which of the following statements is true?
   a. By investigating every accident, management can learn about causes and can take actions towards removing the causes.
   b. By investigating every incident, management can learn about causes and can take actions towards accidents.
   c. Management can learn about causes and can take actions towards removing the causes.
   d. By investigating every incident, management can learn about causes and can take actions towards removing the causes.

8. Match the following.

<table>
<thead>
<tr>
<th>Theory</th>
<th>Definition</th>
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<tbody>
<tr>
<td>1. Biased liability theory</td>
<td>a. There is sequence of factors before an injury takes place and if any of the preceding factors is controlled, injuries do not take place.</td>
</tr>
<tr>
<td>2. Accident proneness</td>
<td>b. People who fail to reach some sort of adjustment with working environment may have more accidents than others.</td>
</tr>
<tr>
<td>3. Adjustment stress theory</td>
<td>c. There are certain people who are injured more than others.</td>
</tr>
<tr>
<td>4. Domino’s theory</td>
<td>d. Once a person sustains injury, the chances of his getting injured again are either decreased or increased.</td>
</tr>
</tbody>
</table>

   a. 1- a, 2- b, 3- c, 4- d
   b. 1- d, 2- c, 3- b, 4- a
   c. 1- b, 2- c, 3- a, 4- d
   d. 1- c, 2- d, 3- a, 4- b

9. A workman, who is injured and has given notice of an accident to the employer, shall submit himself for medical examination by the __________.
   a. employer
   b. medical officer
   c. himself
   d. family

10. Unsafe acts include which of the following?
    a. Insufficient workspace lighting
    b. Excessive noise
    c. Slippery or unsafe flooring
    d. Actions or failures to act which result in injury.
Chapter V
Ergonomics and Cumulative Trauma Disorders

Aim
The aim of this chapter is to:

- define application of ergonomics in workplace
- elucidate cumulative trauma disorders
- explain how stress and addictions can affect health

Objectives
The objectives of this chapter are to:

- define chronic backache
- explain disorders of the upper extremity
- state periodic health surveys

Learning outcome
At the end of this chapter, the students will be able to:

- explain disorders of the lower extremity
- understand control through human factors engineering
- define Arteriosclerosis and Hypertension among executives and non-executives
5.1 Introduction
Ergonomics comes from the Greek words ‘ergon’ (work) and ‘nemein’ (to arrange or manage). Today we understand it to mean a study of the fit between a person and the elements of the task they are required to perform. Management has to see that the workplace is often determined by the design of the machine and the methods that the employees will use are not harmful to their health and wellbeing, but promotes them to perform their task safety, easily, comfortably and effectively. Most management people are aware of the necessity to care for equipment but when it comes to the care of employees they often will have to think on their own. Undue torture to the human body or any part of the body results into various types of disorders. Excuses or improper uses of fingers lead to complaints starting from simple pain and fatigue to permanent incapability by neurological or tendon affections. Frequent movement of eyeball leading to working of eye muscles results into various eye complications. Frequent improper movement of shoulder to joint pains and rupture movement of capsules, wrist movement in improper way to C.T.S. etc are well recognised.

5.2 Levels at Workplace Involving Ergonomics
Three different levels of work which involve ergonomics can be found in the workplace. They are work station design, workplace design and job design.

- Work station design involves the disciplines- anthropometry and biomechanics (which involves functional anatomy and physics)- as well as engineering and psychology. Psychology is involved because it looks at how people receive information or stimuli; how they process this, or these, in the brain; how they make decisions; and then how they act upon them. Experience and training can improve perception and decision making. Perception of some stimuli, such as visual ones, is affected by old age.

- Workplace design involves fitting work stations into the overall physical design of a workplace. This will include issues such as noise, temperature, lighting, colour and rational movement of people and materials.

- Job design takes into account what has been said above, but also looks at the way tasks are broken up, the decision-making processes and the operations of work groups. Important considerations are level of mental stimulation (under or over); conflict between different people and different work areas; meaning in the work; and degree of control (consultation). Thus motivation and hence safety culture are important elements in this.

The psychology of errors and types of errors are important aspects of safety. Physiology plays a part in examining the way people perform, particularly in extremes of temperature and humidity. The body parts which are most susceptible to be affected due to none or poor considerations of human factors in workplace are:

- Upper extremity (shoulder, elbow, wrist, hand and fingers)
- Lower extremity (knee, ankle and foot)
- Back (spine and muscles surrounding them)

The disorder progresses slowly but at accumulative in nature and with time gap if manifest into a major medical problem.

5.3 Chronic Backache
A permanent feature among the industrial workers is due to the non-proper support leading to muscular strain is responsible for less productivity due to chronic absenteeism and medical response. This affects them in three dimensions economically, socially and psychologically. Naturally, the result is less output. Therefore, it is high time to care for Man equally, if not more than machine, money and material.
5.4 Disorders of the Upper Extremity
Disorders of the upper extremity due to improper workplace or tools or work methods are as follows:

Ergonomic aspect of hand and wrist
In every day use there are three basic types of work carried out by the hand:
• To grasp: Cylindrically or spherically.
• To pinch: By tip pressure, by pulp pressure or by lateral pressure.
• To hook: Three main group of muscle act on the fingers. They are long extensors, the intrinsic and long flexors.

The ranges related to hand and wrist:
• the range of movement of proximal joints is \(90^\circ\)
• middle joints of the fingers are \(100^\circ\)
• the average range of abducted thumb is \(58^\circ\)
• extension \(71^\circ\)
• flexion \(73^\circ\)
• radial deviation \(19^\circ\)
• ulnar deviation \(33^\circ\)

5.5 Cumulative Trauma Disorders
When this normal movement of the hand and wrist are stretched upon to perform certain job either by frequently or by stress, disorders take place. Even within the range of motion due to frequency adverse effects manifest. The disorder collectively called as cumulative trauma disorders. It includes following disorders:
• Tenosynovitis
• De quervain’s diseases
• Trigger finger
• Tendinitis
• Tennis elbow
• Carpal tunnel syndrome
• Raynaud’s syndrome
• Space invaders wrist

Tenosynovitis
The term applies to pathological disturbances affecting one or more tendons and/or more they sheet with the clinical features of pain, swelling, crepitus and loss of function. It occurs in the industrial situation where the job requires wrist deviation from side to side, for example, to hold in line nut runner in a horizontal position or where frequent movement is needed to operate the various control panels. The workers start with pain in the beginning and if not taken the care will end with a permanent deformity due to loss of function.

De Quervain’s diseases
This is an affection of the tendons of long abductor and sometime the short extensor of the thumb, due to fibrosis of the sheath and narrowing of the intrathecal lumen. This occurs usually among the workers who have to use their thumb for a great deal to perform the job. It is especially common among the women workers who perform repetitive manual task involving inward or outward hand movement with firm grip. In this condition pain is severe in the wrist and sometime also radiates to the forearm. Weakness of thumb and wrist results ultimately with permanent deformity.
**Trigger finger**
It is a type of tenosynovitis and result in workers when any fingers other than thumb are frequently flexed against resistance during the performance of a job.

**Tendinitis**
Muscle tendon junction and muscle tissue around gets fatigued because of the frequent abduction of the movement. The main muscle body stretches away from the middle of the body to which it is attached leading to inflammation. This is very commonly found among the industrial workers and mostly in the degenerative diseases of the shoulder joints.

**Tennis elbow**
This is also called epicondylitis. In this condition pain appears near the epicondyl on the outer side and is due to the chronic inflammatory reaction of the tissue in the elbow region. In the industrial situations it follows the effort requiring palm upward, extension of the wrist with palm downward. It can be avoided by ensuring that the rotation axis of the tool or machine comes inside with the rotation axis of the forearm.

**Carpal tunnel syndrome**
It is a common disorder amongst the industrial workers, caused by the compression of median nerve in the carpal tunnel, in the wrist through which finger flexors and major nerve passes to the hand from the forearm. It is characterised by tingling, pain numbness in the thumb and the first three fingers. In this condition manipulative skills of workers are reduced. In industrial situation a job requiring repeated wrist flexion, for instance, to position a pistol separator runs on a horizontal surface.

**Rayanud’s syndrome**
This is defined as an episode of contraction of the small blood vessels in the periphery of the extremity resulting in permanent changes in colour of the skin such as pallor or cyanosis or both (this may be due to cold temperature), vibration in the industrial situation. This leads to reduced and improper manipulative skill.

**Space invader’s wrist**
Symptoms include feeling of stiffness, headache and numbness with swelling and spasm of muscles during movement or even on a postural change. This is a very common in the electronic industries where the finger movement is required frequently and with proper tools.

### 5.6 Disorders of the Lower Extremity
The human foot has two major functions:
- While standing it must provide a suitable support for the body weight i.e. balance.
- While walking it must in addition to support the body weight provide level by which the body is propelled. Ankle joint and knee joint are the important component for the overall function of the inferior extremity.

Disorders of the lower extremity due to workplace or tools of work methods are as follows:

**Ergonomic aspect of foot**
Normal movements at the ankle joint are dorsa-flexion $18^\circ$, planter flexion $45^\circ$, inversion - $33^\circ$, aversion $18^\circ$. While sitting or performing any job, this range of motion is tortured they result in disorders like foot strain, osteoartheritis halleus, valgus, metatarsalgia, kohaler’s disease, chronic bursitis, etc. Due to the pain and difficulty in negotiating the function of the foot the efficiency of the worker reduces beside his physical problems.

**Low back pain**
Postural errors, assumed in the course of some occupation leads to low back pain. These pains are because of the interference with the functions of normal muscle, when muscles go under postural strain leading to spasm usually in the lumbo-sacral region or on sacro iliac region joint disorders of the part result. Any occupation requiring long work hours with improper posture should be avoided.
5.7 Controls through Human Factors Engineering

To prevent disorder human factors engineering has to play a great role. The discipline which comes to play their role in prevention of them is the bio-mechanics. Its principles in view of the applicability must be used while designing machines, workplaces and methods to be used by the employee to perform their task. The main bio-mechanic problems which can help in prevention of occupational health disorders are as follows:

**Straight back rule**

All the forces which come down the spine compresses the intervertebral discs and as a result of continuous and repetitive squeezing they can rupture and bulge out producing severe pain. Most back injuries are built over a long period of time by repetitive pounding of the discs, caused by improper methods. After sometime some minor life can produce such rupture even lifting a small pin. Straight back rule helps to design methods to minimise the forces on these discs. To avoid such forces, one should use Pelvic tilt by pulling the stomach muscles. The pelvic tilt can also be achieved by placing support under one leg. When bending cannot be eliminated through workplace or methods designed, it could be done with keeping the back straight and bending the legs. Any banding without lifting, twisting, impacts and frequent change of position should be avoided by proper designing of the workplace and work methods. When seated a support for the back to keep the muscles away from getting fatigued should be used.
Belly button rule
 Loads that are held, lifted or carried should be kept near the belly button. The weight of 30 pound load next to the belly button (above 8” away from spine) exerts 240”/pounds, whereas when weight is moved out 12” from the belly button, it would be 20” from the spine and the load on the spine will be now 600”/pounds. Therefore, the workplace and methods should be designed so that work requiring the use of arms is close to the belly button. When the arm is extended in performing a task the muscles of the arm cannot work to the best of their capability.

Swinging arm rule
 Methods and workplace should be designed to promote workers to use natural movement and should not be forced to move leads with hands or arms in a straight line. A natural swing of arms take 33% less muscle strain than moving the arm in a straight line. Positive steps should be used to stop load movement rather than to use muscle power.

Straight wrist rule
 In jobs requiring repetitive pushing or pulling thumb should be used instead of any of the middle fingers jobs requiring grasping movement for the hand should be designed in such a fashion so that there is no bending of the wrist while performing the job. Continuous bending of wrist can lead to the disorders like carpal tendon syndrome. Some tools such as hammers, pliers have been designed with a suitable band in their handles so that they can be used with wrist straight.

Eye rule
 Workplace should be so designed that the worker can see all the things to be sun like gases controls and materials etc. without excessive undue or head movement.

Skin rule
 According to this rule, the work area should be free from obstruction and there should not be a concentrated pressure on small skin areas. Wherever it is found that the workers used a tape or cloth over the part of the machine while operating, it means that this piece of machine is hurting him because of the accumulated pressure on a particular part of the skin. This needs immediate attention to be changed so that the works without any obstruction.

The think first rule
 Human tendency is to take a short-cut or do something that is easy rather than safe. This should be avoided. Therefore, before doing, thinking must be applied so that the job becomes safe for worker.

No brain machine rule
 At the time of designing job or machines it should be taken into consideration that if worker did not think when he performed the task, could he get hurt? If the answer is yes, necessary change in designing is indicated. Sufficient statistics on the number of workers suffering with various disorders due to improper designing of the machines or the workplace are lacking but the limited data which are available clearly indicate about the seriousness of the situation role of human factors engineering in their prevention.

5.8 Checklists
 The following are the checklists which may assist you in applying biomechanics to your tasks and machine design. You need to have a “yes” answer to each question.

Task element checklist
 • Is the element necessary?
 • Are all movements, holds and delays necessary?
 • Is the back straight?
 • Is the back free from twisting?
 • Are elbows by the side of the arms?
 • Are movements natural and ballistic?
- Are wrists straight?
- Is work area free of obstruction?
- Are stop switches, controls, lock outs and guards convenient and adequate?
- Is the weight lifted less than 32.2 – 1.2 x the number lifts per minutes and is the weight carried less than 32 lbs?

**Machine design checklist**
- Is equipment operated with back erect, no twisting, supported if seated, foot rest if standing?
- Are control and materials near stomach and in sequence of use?
- Can operator’s movements be ballistic?
- Can equipment be operated with straight wrists?
- Are readouts and gages simple, in sequence, and do not require head movements?
- Are handles and surfaces not applying pressure on small skin areas?
- Are stop and off switches where operator will be?
- Are guards easy to remove and replace without tools?
- Does equipment require minimum tools which are displayed in order to use?
- Is there accumulation of material before and after machine operation?

### 5.9 Health of Executives

Health of the executives has received considerable attention in recent years and that too for good reasons. Not only the prosperity or loss of the business but also the maintenance of good human relations and the fortunes of the numerous employees depend on their decisions. A sudden death of the executive means sudden disturbance of the smooth running of a business and leaves an invalid that cannot be easily filled socially in a developing country. Business, therefore, is genuinely interested to see that the men who guide its destinations are kept hundred percent fit.

One other factor that has helped the subject to attract public attention is panic created by press and incomplete survey report on executive health. These reports have created such a frightening picture that executives themselves have started believing that they must pay the penalty of being an executive in the form of ill health and sudden death. People have started calling a group of ailments as “executives”. The typical executive, according to these reports is under severe strain, subjected to constant heavy pressure of modern business, and is tired, tense and overworked. As a result, he develops ulcers, sleeplessness, high blood pressure and meets with an early and sudden death.

**Transformation in state of awareness**
- Fortunately, over the years, this picture of executive health has undergone changes as result of scientific investigation.
- Studies have been undertaken by Medical Associations, Life Insurance Companies and Industrial medical officers in different countries mainly in the United States and the United Kingdom.
- A fund of information has accumulated as a result of extensive group health studies, researches and periodic health check ups of executives.
- These studies pointed out that the executive is no worse off than any other younger – in fact he has a higher life expectancy.
- The worst that can be about his health is that he is subjected to the same hazards to health as doctors, lawyers, civil servants and all those who belong to the higher income group (or Social Class I).
- To consider their health problems in any other way would be vague realities and separate them in a random and invalid fashion from their fellows who do not work in industry and commerce.
- In a study undertaken by Lee and Schneider it was found that there was significantly less arteriosclerotic diseases among executives than expected and no relationship between level of responsibility and incidence of either hypertension or microbial infection was seen. Possibly, executives are healthier than workers to start with or have means or releasing their tension or take proper care of themselves than other workers.
5.10 Arteriosclerosis and Hypertension among Executives and Non-Executives

<table>
<thead>
<tr>
<th>Disease (an impairment of health or a condition of abnormal functioning)</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Executive</td>
<td>11%</td>
</tr>
<tr>
<td>Executive</td>
<td>9%</td>
</tr>
<tr>
<td>Minor Executive</td>
<td>13%</td>
</tr>
<tr>
<td>All Executive</td>
<td>12%</td>
</tr>
<tr>
<td>Non Executive</td>
<td>13%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arteriosclerosis (General term for the thickening and the hardening of arteries. Its development is accelerated by high blood pressure.)</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Executive</td>
<td>11%</td>
</tr>
<tr>
<td>Executive</td>
<td>9%</td>
</tr>
<tr>
<td>Minor Executive</td>
<td>13%</td>
</tr>
<tr>
<td>All Executive</td>
<td>12%</td>
</tr>
<tr>
<td>Non Executive</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Myocardial infarction (death of the heart muscle due to insufficient blood supply, usually due to clot obstructing blood flow)</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top Executive</td>
<td>4%</td>
</tr>
<tr>
<td>Executive</td>
<td>4%</td>
</tr>
<tr>
<td>Minor Executive</td>
<td>3%</td>
</tr>
<tr>
<td>All Executive</td>
<td>4%</td>
</tr>
<tr>
<td>Non Executive</td>
<td>5%</td>
</tr>
</tbody>
</table>

Table 5.2 Arteriosclerosis and hypertension among executives and non-executives
(1,171 male executives and 1,203 non–executives of whom, 563 were females. R.E. Lee and R.F. Schneider Journal of American Medical Association page 1147, July 19th 1958.)

- This information may deprive a few executives of the pleasure of considering themselves ‘martyrs’ (of prosperity), but it is very heartening to know that there is nothing about this occupational that might bring about an early death or informative in fact in many respects the executives are much better placed. Our experience in this country is similar to the findings of the Western countries. We find not only the mortality rate amongst our executives is much better placed, but that the executives suffer from less number of illnesses as well.
- This does not mean that nothing needs to be done about the health of the executive. In fact there is much that can be done to enjoy better health, to increase fitness and to avoid some of the ailments that affect them.
- A positive approach to health and sober living habits may cure a larger number of ailments that are common to them. There are many illnesses and deformities that come un-obstructively and make their presence known only when they are far advanced, for example Diabetes. If this disease is detected early and simple precaution is taken, like controlling the diet, then one can easily prevent its further progress, keep it under control and lead a perfectly normal life.
- There is a host of other diseases of this category. To detect them early, a thorough check up or health supervision must be undertaken periodically. There is nothing unusual in this advice. It is insisted that the machines used in factory or car engine should be periodically checked and attended for proper maintenance. Such check ups would avert a major disaster. If this is necessary for an engine, should it not be more necessary for a far more complex system of engines, which is human body? This is not only necessary, but is essential if we want to remain healthy and hundred percent fit.
5.11 Periodic Health Surveys

The purpose of the periodic health examination is to evaluate health status, screen for risk factors and disease, and provide preventive counseling interventions in an age-appropriate manner.

- The goal of screening and evaluation is to prevent the onset of disease or the worsening of an existing disease. For example, measurement of blood pressure is intended to detect hypertension so as to initiate treatment and prevent subsequent morbidity (e.g., stroke or renal failure) or mortality.
- A further goal of the periodic health examination is to educate patients about behavioral patterns or environmental exposures that pose risks for future diseases. Examples include counseling about smoking prevention and cessation to prevent lung cancer and emphysema, seat belt use to prevent motor-vehicle injuries, or modifying sexual practices to prevent the spread of sexually transmitted disease.
- Periodic health examinations are often taken for granted, especially in developing countries like India where people avoid visiting a health professional as far as possible and do so only when they suffer from some illness.

Importance of screening

- A careful history and a physical examination are important parts of the periodic health examination.
- The patient history elicits following conditions:
  - recent and current symptoms or complaints;
  - medications being taken (and any allergies to medications);
  - an accounting of the past medical history of the patient;
  - the social factors that may impact on the health of the patient (e.g., marital status, household makeup, employment);
  - a family history of illnesses affecting family members;
  - a review of signs and symptoms for each of the organ systems in the body.
- The physical examination consists of three modalities to gather information: inspection, auscultation, and palpation. These methods are applied in a systematic way to the major systems of the body.
  - Inspection involves observation of the body part being examined. The general appearance, color, and any other visual characteristics are noted.
  - Auscultation involves listening, often with the aid of a stethoscope. The quality of any sound is noted, including loudness, musical tones, and effect of change in position.
  - Palpation involves feeling both the size and texture of organs under examination.
- The major areas of the body to be examined are the head and neck, chest, abdomen, extremities, skin, musculoskeletal system, and nervous system.
- Using the three modalities in conjunction with the patient’s medical history and screening tests allows an assessment of the overall health of a patient.

Rule of thumb

- The need for increasing the frequency of these check ups also increase with advancing area. We think that these above 40 years of age should have a check up every year, while those below this age group may have it every two or three years. This of course is a ‘rule of thumb’ and one should be guided by one’s own doctor.
- The time for medical check up is also the time when inoculations and vaccinations should be taken for protection against epidemics like small pox, cholera, typhoid etc. It is not early to detect diseases particularly those that have functional or emotional origin.
- One must therefore help the doctor by confiding and hiding nothing, full cooperation in necessary. It is not sufficient to restrict discussions to physical ailments alone. A frank discussion about one’s problem at home, office and friends that are affecting emotionally, is also necessary. Only then the doctor can give useful health counselling which need not be restricted to physical health alone guidance and first aid to emotional health are equally vital.
A significant point to remember about periodical medical examination is that it can only detect what is present but cannot predict about future ailments. A normal healthy heart today does not mean that it cannot be diseased in future.

The following are observations: (Non-executives here means office staff, factory workers and salesman)

- Incidences of certain diseases like tuberculosis, anemia, deficiency diseases are significantly lower (almost non-existent) among the executive group.
- The incidences of common ailments like cold, diarrhea, dysentery etc. are comparable in both groups but the incidences of lower respiratory tract infections like bronchitis, pneumonia are less amongst the executive group.
- The incidences of diabetes, obesity, hemorrhoids, joints ailments, low backache are higher amongst the executives.
- There is no significant difference in the incidences of peptic, ulcer, coronary heart disease, high blood pressure in the two groups, but the incidences and mortality due to heart diseases (of all varieties) are lower in the executive group.
- There is an increase in incidences of minor functional diseases like headaches and liable hypertension.
- The total volume of sickness (all types causing absence is less amongst the executive group than among the non-executives and the number of work days lost due to sickness is about one-third per head in the executive group as amongst the non-executive group. This may be atleast partially due to the fact that executives tend to have a greater sense of responsibility and do not remain absent for minor ailments.

### 5.12 Factors Affecting Health

#### Overeating

It is said that overeating is an ‘occupational hazards’ of the executives. Frequent official lunches, banquets and sumptuous dinners expose them to rich type of food, highly spiced and over cooked with plentiful amount of fat. In between snacks, sweetened drinks and cocktails add up to the number of calories and naturally the waistline imperceptibly goes on increasing. Take off the excess weight in a slow but steady manner (a reduction of 4 to 5 lbs. per month is satisfactory) by making a habit of eating the desirable amount of food. There is no need to go on a strict diet; the effect of this may be dramatic rarely permanent. The best way to reduce is to eat less, avoid excess fat like butter, ghee and oil, fired foods, excess carbohydrates like rice, potatoes, green peas, sweets and avoid snacks in between meals, add plenty of salads, green leafy vegetables and fruits in your diet.

#### Smoking

There is no doubt that smoking is bad for health. Cancer of lungs is 42 times more often among those who smoke 40 cigarettes a day than among non smokers. The higher the number of cigarettes smoked, the higher the chances of lung cancer. It has also seen that in people about 40 years, the incidence of coronary heart disease is three times more prevalent among smokers than among non-smokers.

#### Drinking

Many young executives, initiated at the office cocktail parties, find it difficult to do without it. Medically a peg a day is not harmful to health but is should never be more than two pegs under any circumstances. In certain individuals, a drink may help to relax, but since it provides extra calories (about 100 calories for one oz) and makes one hungrier those, who have to reduce weight, should never touch it.

#### Exercise

Some amount of physical exercise daily helps a lot. For example, strenuous gymnastic, walking, swimming, playing golf, tennis etc. that one likes. The human body is made for movement and functions well when the parts are moved regularly. Sedentary habits, enforcing disuse of the muscles and joints, lead to a number of ailments like joint pains, low backaches etc. Exercise helps to improve circulation of these parts, tone them up and prevent or at least delay the onset of changes that come with advancing age. Physical exercise also helps to burn up the excess calories and keep the body fit and trim. This is also the best way of relaxing. It has been shown in repeated studies that those
who do regular physical exercise suffer much less from heart attacks than those who are inactive in habit. Walking is the best exercise for any age, especially so for the elderly. It is a fine initiative to use the staircase rather than the lift so long as you do not get uncomfortably breathless.

**Sleeping**
Approximately seven to eight hours of sleep is necessary for normal individual. Insufficient sleep produces a state of constant tiredness and fatigue apart from increasing tension. Exercise and relaxation are the best means of getting sleep. Sleeping tablets should not be used.

**Relaxation**
The business executive is proverbially a tense person - a victim of stress and responsibility. There is no doubt that excessive stress is harmful but human beings in every core of activities of life have to face stress. Normally in small amounts it helps to keep alert and lively. Only when it goes on accumulating ailments start. Peptic ulcer, coronary thrombosis, high blood pressure, excessive thyroid activity, certain skin disorders and asthma are at least partially stress disorders. It is therefore very necessary that everyone, especially the business executives must know how to relax. Hobby, sports, exercise, spending sometime with children in the evening, all these are excellent means of relaxation. One way of avoiding unnecessary amount of stress is to develop the right attitude towards life.
Summary

- Ergonomics comes from the Greek words ‘ergon’ (work) and ‘nemein’ (to arrange or manage).
- Management has to see that the workplace is often determined by the design of the machine and the methods that the employees will use are not harmful to their health and wellbeing, but promotes them to perform their task safety, easily, comfortably and effectively.
- Work station design involves the disciplines- anthropometry and biomechanics as well as engineering and psychology.
- A permanent feature among the industrial workers is due to the non-proper support leading to muscular strain is responsible for less productivity due to chronic absenteeism and medical response.
- Hobby, sports, exercise, spending sometime with children in the evening, all these are excellent means of relaxation.

References

- Davies, Sir Daniel, Stores and Responsibility, The Health of Business Executive : Transactions 1959 by the Chest and Heart Association of London
- O’Dwyer, J.J. Overwork and Fatigue : Age 26 – 31 : The Health of Business Executives, transactions 1959 by the chest and Heart Association of London.

Recommended Reading

- Charles E. Geisel – “Are your procedure a menace” article published in National Safety News, USA.
Self assessment

1. __________ involves the disciplines- anthropometry and biomechanics as well as engineering and psychology.
   a. Work station design
   b. Job station design
   c. Workplace design
   d. Job station

2. __________ is involved because it looks at how people receive information or stimuli.
   a. Sociology
   b. Physiology
   c. Psychology
   d. Biology

3. Which of the following statements is true?
   a. Frequent movement of eyeball leading to working of eye muscles is helpful for good vision.
   b. Frequent movement of eyeball leading to working of eye muscles results into various eye complications.
   c. Improper uses of fingers lead to shoulder pain.
   d. Frequent improper movement of shoulder affects on wrist joint.

4. Which of the following statements is true?
   a. Experience and training can improve perception and decision making.
   b. Experience and age can improve perception and decision making.
   c. Experience can bring change in perception and decision making.
   d. Decisions are completely depend upon the age of the person.

5. __________ involves fitting work stations into overall physical design of a workplace.
   a. Work station design
   b. Job station design
   c. Workplace design
   d. Job station

6. Which of the following statements is true?
   a. Motivation and safety culture are important elements in job design.
   b. Meaning in the work is important in job station design.
   c. Issues such as noise, temperature, lighting, and colour are considered under workplace design.
   d. Degree of control is important in work station design.

7. __________ plays a part in examining the way people perform, particularly in extremes temperature and humidity.
   a. Psychology
   b. Biology
   c. Physiology
   d. Sociology
8. __________ occurs in an industrial situation where the job requires wrist deviation from side to side.
   a. Cumulative Trauma Disorders
   b. De Quervain’s diseases
   c. Trigger finger
   d. Tenosynovitis

9. __________ occurs usually among the workers who have to use their thumb for a great deal to perform the job.
   a. Trigger finger
   b. De Quervain’s diseases
   c. Cumulative Trauma Disorders
   d. Tenosynovitis

10. ___________ leads to reduced and improper manipulative skill.
    a. Rayanud’s syndrome
    b. Space invader’s wrist
    c. Carpal tunnel syndrome
    d. Tennis elbow
Chapter VI
Personal Protective Equipment

Aim
The aim of this chapter is to:

• define personal protective equipment
• explain different types of personal protective equipment
• elucidate personal protective equipment used in industries

Objectives
The objectives of this chapter are to:

• elucidate various processes in personal protective equipment used
• explain the requirements of personal protective equipment
• define selection of respirator

Learning outcome
At the end of this chapter, you will be able to:

• define types of personal protective equipment
• explain non-respiratory protective equipment
• elaborate legal requirement
6.1 Introduction

Personal protective equipment (PPE) refers to the respiratory equipment, garments, and barrier materials used to protect rescuers and medical personnel from exposure to biological, chemical, and radioactive hazards.

Scope and application

The Occupational Safety and Health Administration (OSHA) requires PPE to be provided, used, and maintained in a sanitary and reliable condition wherever hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants are encountered in a manner capable of causing injury or illness through absorption, inhalation, or physical contact. Departments are responsible for ensuring the adequacy of the equipment and ensuring that it is properly maintained, even in those cases where employees provide their own PPE. Following are some important points regarding PPE:

- The goal of personal protective equipment is to prevent the transfer of hazardous material from victims or the environment to rescue or health care workers.
- Different types of PPE may be used depending on the hazard present. The types of hazards addressed here include biological warfare agents (BWAs), chemical warfare agents (CWAs), and radioactive agents.
- The most common routes of exposure to these hazards include inhalation (breathing, from the air), skin contact, and ingestion (eating or drinking).

6.2 Requirements of Personal Protective Equipment

Personal protective equipment (PPE) refers to protective clothing, helmets, goggles, or other garment designed to protect the wearer’s body from injury by blunt impacts, electrical hazards, heat, chemicals, and infection, for job-related occupational safety and health purposes, and in sports, martial arts, combat, etc.

- The use of personal protective equipment is to reduce employee exposure to hazards when engineering and administrative controls are not feasible or effective to reduce these risks to acceptable levels
- Requirements of suitable personal protective equipment can be listed as under:
  - Nature of the hazard
  - Severity of the hazard
  - Type of contaminant
  - Concentration of the contaminant
  - Duration of work
  - Location of the contaminated area with respect to a source of respirable air
  - Expected activity of the wearer
  - Operating characteristic and limitations of the equipment
  - Reliability of the equipment
  - Acceptance of the wearer
  - Cost of the equipment

6.3 Limitations of Protective Equipment

The use of any type of personal protection equipment requires adequate training. The overall goals of training are to protect the wearer from physical hazards (biological, chemical, radioactive) and to prevent injury from improper use or equipment malfunction. Personal protection equipment has its limitations:

- Takes time to put on.
- Difficult to perform tasks while wearing the equipment: Some first responders or emergency care personnel may experience difficulty in performing some life-saving interventions.
- Hard to move around while wearing the equipment: Mobility decreases with weight. Mobility also is limited by using a SAR, because the wearer must retrace his or her steps along the supplied air line to exit the hot zone.
- Difficult to communicate: Someone wearing a face piece or mask is difficult to understand.
- Hard to see: Face pieces also may limit the wearer’s visual field.
- Full protection suits become hot inside: Encapsulation and moisture-impermeable CPC material lead to heat stress.
- Psychological stress: Encapsulation increases the psychological stress to wearers and victims.
- Can’t wear suits for long periods of time: Wearing level A PPE for longer than 30 minutes is difficult.
- Limited oxygen availability: SCBAs (Self Contained Breathing Apparatus) only can be used for the period of time allowed by the air in the tank. APRs (Air Purifying Respirator) only can be used in environments in which the outside air provides sufficient oxygen.

PPE also is associated with potential hazards or risks to wearers, which are as follows:
- Improper use: Protective respiratory devices and CPC (Chemical Protective Clothing) must be properly fitted, tested, and periodically checked before use.
- Penetration: If the equipment does not fit properly, the hazardous agents may penetrate the equipment, and the wearer may become contaminated. Also, certain chemicals may break down the equipment, which would have to be replaced.
- Recontamination: Wearers may become contaminated as they remove their equipment unless decontamination and removal protocols are followed carefully.

### 6.4 PPE Training
Each worker required to use PPE must receive training in the following:
- how to properly wear PPE
- what types of PPE provide protection against the hazards identified during the assessment
- when PPE must be used
- the proper care and useful life of PPE
- proper disposal of damaged PPE

### 6.5 Legal Requirement
In the Factories Act 1948, there are specific provisions for providing the personal protective equipment to the worker who are exposed to unsafe and unhealthy environment. The provisions of law relating to use of personal protective equipment in different operations and processes are framed in such a spirit that the workers working on the operations and in the processes are protected against possible hazards. It is also the intention of the law that this personal protective equipment shall be of such type and made of such materials that it withstands to such specific hazards for which it is actually being used.

### 6.6 Responsibilities of Head of Department and Line Managers
The Head of Department or Line Manager has the following responsibilities:
- To ensure suitable and appropriate PPE is provided. This means that the PPE should be appropriate for the risk or risks involved and the conditions where it will be used.
- The PPE should take account of ergonomic requirements and the state of health of the person who is required to wear it.
- To carry out the assessment on the suitability of the PPE on all items of PPE prior to starting work. A record should be kept.
- To maintain and replace PPE as necessary. This should be done in accordance with the manufacturer’s advice where appropriate. A record should be kept of this.
- To provide adequate and suitable storage for all PPE.
- To provide information, training and instruction for employees therefore enabling them to make proper effective use of PPE.
Training for PPE users must include the following:

- An explanation of the risks presents and why the PPE is being used.
- How to operate the PPE and any limitations of the equipment which may affect the protection offered.
- Instructions on the storage of the PPE.
- The arrangements for reporting loss or defects of the PPE.

Responsibilities of employees

It is the responsibility of an employee to use PPE in accordance with training and to report any loss or defect immediately. The employee also has a responsibility to return PPE to its place of storage after use.

6.7 Types of Personal Protective Equipment

Personal protective equipment for various parts of the body can be divided into five broad groups:

- **Head Protection**: Head protectors may be hard hats and caps made of aluminum, PVC fiber glass, laminated plastic or vulcanised fiber. They may be fitted with brackets for fixing welding masks, protective face screen or a lamp. The hats and caps are provided with replaceable hardness which provides sufficient clearance between the top of the head and shell. Safe caps and hoods are also used for protection against heat, spark and other dangerous materials and are made of appropriate materials. Sometimes hoods are made with rigid frame which is held away from the head.

  **Equipment**: Hats, caps and helmets

  **Material Hazard**: Asbestos, sparks, hot materials heat, plastic rubber, hot liquids, moisture, acids, alkalis, electric shocks and dermatitis.

- **Eye and Face Protection**: Numerous eye injuries are caused by dusts, flying particles, splashes and harmful radiation. It is difficult to cover precisely the various processes in which the worker may be required to wear goggles. Eye protectors may be safety spectacles, mono-goggles, impact goggles, welding goggles, foundry goggles, chemical goggles, face shields, welding helmets, etc. The following hazards may be encountered:

  **Relatively Large Flying**: Chipping, felting, riveting, sledging caulking, etc. Dust and small flying objects: Scaling, grinding, stone dressing, wood working.

  **Splashing of Metals**: Babbiting, pouring of lead joints, casting of metals, galvanising and dripping in molten metals.

  **Splashing of Liquids, Gases and Fumes**: Handling of acids and other chemicals.

  **Reflected Light, Glare and Radiant Energy**: Resulted from foundry work, glass furnaces, gas welding and cutting arc welding.

- **Hand and Arm Protection**: Protection of hands and arm become necessary when workers have to handle materials having sharp edges; or when hot and molten metals, chemicals and corrosive substances have to be handled. The protective equipment may be gauntlet gloves, wrist gloves, mittens, hand pads, and thumb and fingers guards and sleeves. It is important not only that the various parts of arm and hand are adequately covered, but that they should be covered by a material suitable for withstanding the specific hazard involved.

  **Equipment**: Gloves, mittens, pads, and finger guards.

- **Foot Protection**: Common foot and leg protective equipment are safety shoes and boots, leggings, foot guards and leg guards.

  **Equipment**: Knee pads, leggings, shoes and boots

  **Material Hazard**: Asbestos, sparks, hot material and heat, chrome leather, sparks, hot materials, hot liquids, flying particles and cuts and abrasions, flame proofed duck, sparks, hot materials, heat, flying particles and machinery, plastic, hot liquids, moisture, acids, and alkalis.

  **Dermatitis**: Plastic, hot liquids, moisture, acids, and alkalis.
Body protection: Sometimes it becomes necessary to provide special protective equipment for the body in the form of aprons, jackets and complete head to toe protective suits. Degree of the hazards and nature of activities of the user concerned are important consideration in the selection of safety and clothing. Although complete coverage of the legs is not needed in many cases and unnecessary safety clothing may occur the efficiency of the user, no compromise should be made with strict safety requirements. If a user needs complete coverage, he should have it.

Equipment: coats, aprons and waist

6.8 Characteristics of Respiratory Protective Equipment
Atmospheric contaminants range from the relatively harmless substances to toxic dusts, fumes, smokes, mists, vapour and gases. Processes, which present hazards of exposure to harmful substances should, if possible, be closed or ventilated to eliminate or minimise the hazard.

- Respiratory equipment should be provided to the workers exposed to possible hazard, if enclosure ventilation or other engineering means of control are not possible or become very costly to apply to the degree required for ensuring absolute safety.
- Even though engineering measures of control are applied satisfactorily, a supply of appropriate protective equipment should be readily available for use, as there will be plant breakdowns and repairs may have to be carried out in contaminated environments.
- Respiratory protective equipment should be considered a last resort, or stand by protection and never a substitute for effective engineering control.

6.9 Classification of Hazards
Type of hazards to which a worker is exposed is the basis of selection of the right type of respiratory protective equipment. The hazards may be classified as under:

**Oxygen deficiency**
- Atmosphere in confined spaces such as waste tanks holds of the ships, etc may contain air with oxygen content much lower than the normal (21% by volume).
- This may be due to dilution or displacement of the air by other gases or vapours or because of loss of oxygen due to decay of organic matter, chemical reaction and natural oxidation over a long period of time.
- A person breathing air with oxygen content of 16% or less may exhibit symptoms ranging from increased rate of breathing, acceleration of pulse rate to unconsciousness and death.
- Such oxygen deficiency conditions can easily be detected as the flame of a safety lamp will be extinguished in such atmosphere.
- The respiratory protective equipment in such conditions, should either supply normal air or oxygen to the wearer.

**Gaseous contaminants**
These may be toxic or inert gases. The toxic gases may produce harmful effect even if they are present in relatively low concentrations. The inert gases produce undesirable effects primarily by displacement of oxygen.

**Gaseous contaminants immediately dangerous to life:**
These contaminants are gases present in concentration that would endanger life of a worker breathing them even for a short period of time. Where it is not possible to determine the extent of concentration or the kind of gas is not known all gases should be considered as ‘immediately dangerous’ to life.

**Gaseous contaminants not immediately dangerous to life:**
These contaminants are gases present in concentration that could be breathed by a worker for a short time without endangering his life but which may cause possible injury after a prolonged single expose or repeated short exposure. But even after the concentrations of the contaminant are known, no exact formula can be applied to determine if the contaminant is immediately dangerous to life or not.
Particulate contaminants (dusts, fumes, smokes, mists, fogs)

- Majority of particulate contaminants are not immediately dangerous to life. They may be solid and liquid and may be classified into three broad groups.
- Toxic particulate contaminants: These when inhaled may pass from the lung into the blood stream and are then carried to the various parts of the body. The effect may be chemical irritation, systematic poisoning or allergic reactions. Common contaminants in these groups are antimony, arsenic, cadmium, chromic acid and chromates, lead and manganese.
- Fibrosis producing dusts: These dusts do not pass into the blood stream but remain in the lungs and may cause pulmonary impairment. The common examples under this group are asbestos, coal, bauxite and free silica.
- Nuisance dust: These may dissolve and pass directly into the blood stream or may remain in the lungs neither producing local or systematic effects.

Combination of gaseous and particulate contaminants

The gaseous and particulate contaminants may be entirely of different substance like carbon-monoxide and oxides of nitrogen produced by blasting and the dust from the blasted material or they may be the same substances in liquid and vapour form like volatile liquids.

6.10 Type of Respiratory Protective Equipment

Respiratory protective equipment may be classified as under:

**Airline respiratory**: Airline respirator of a face piece (half or full/mask or a loose fitting helmet or hood) to which air is supplied through a small diameter hose. It may be a continuous flow type or a diamond type.

- **In a continuous flow type**: Air is supplied continuously to the face piece helmet or hood. Exhaled air or the excess air entering the face piece escapes to the atmosphere. Air supplied should be at least 110 litres of air per minute to enter the face piece at least 170 litres per minutes to enter the helmet or hood.
- **In a demand type**: Respiratory air is supplied to a face piece when the wearer inhales and the rate are governed by his volume rate of breathing. Air from an air compressed cylinder of compressed air is supplied to the face-piece through a demand valve which is situated by the slight negative pressure created when the wearer inhales. On exhalation the demand valve closes and exhaled air escapes to the surrounding atmosphere through exhalation valve. Helmets or hoods are not used with demand type respiratory.

**Suction hose mask**

It consists of a full face-piece connected to a large diameter flexible hose. The wearer draws in air by his own breathing effort; the hose is attached to the wearer’s body by a suitable safety harness with safety line and the air inlet and of the hose is provided with a filter to arrest particulate matter. Air can be drawn in by aspiratory effort of the wearer up to 30 feet length of the hose.

**Pressure hose mask**

This hose mask is similar to suction hose mask except that the air is forced through a large diameter hose by a hand or motor operated blower. The blower is to be operated continuously while the mask is in use.

**Self-contained compressed air or oxygen breathing apparatus**

This is an equipment by means of which wearer obtains respirable air or oxygen cylinder which is an integral part of the apparatus. In a type self contained breathing apparatus, air or mechanism only when the wearer inhales and the quantity of air or oxygen admitted is governed by his breathing. The wearer’s exhaled air escapes to the surrounding atmosphere.

- In compressed oxygen cylinder recirculation - type breathing apparatus, high pressure oxygen from the cylinder passes through a pressure reducing and regulating valve into a breathing bag.
- The wearer inhales this oxygen through a one-way breathing valve and his exhaled breath passes into a canister containing chemicals to absorb exhaled carbon dioxide and moisture and then through a cooler into the same breathing bag.
• Oxygen enters the breathing bag from the supply cylinder on when the volume of gas in the bag has decreased sufficiently to allow the supply valve to open.
• From respiratory point of view, self-contained breathing apparatus has no limitation as to the concentration of the gas or deficiency in the surrounding atmosphere but other factors or may limit the time that the wearer can remain in a contaminated atmosphere.
• Many gases are very irritating to the skin and many can be absorbed in dangerous amounts through the unbroken skin.

Oxygen regenerating recirculation type
In this apparatus moisture content from the wearer’s exhaled breath reacts with granular chemical in a canister. This oxygen enters the breathing bag from which the wearer inhales through a corrugated breathing tube connecting the bag to the face-piece.

6.11 Air Purifying Respirators
Some of the air purifying respirators are mentioned below:

Canister gas mask
This consists of a canister, containing appropriate chemical, a full face-piece and body harness to hold the canister in place on the body of the wearer. Air is drawn through the canister by the wearer and during its passage through the canister the contaminant present in the incoming air is absorbed in the chemical. The canisters are designed for specific gases and it is very important that the appropriate type as used.

The canister gas mask can only be used in atmosphere not deficient in oxygen and not containing more than 2% by volume of most toxic gases. Also, the life of the canister will depend upon the type of canister, the concentration of gas and the activity of the wearer. Like canister gas mask, chemical cartridge respiratory provides respiratory protection for a period that depends on the type of cartridge used, the concentration of the gas or vapour and the wearer’s activity. It is recommended for low concentration gases and vapours (maximum of 0.1% of organic vapour).

Self rescue type respirators
This is designed to provide the greatest possible respiratory protection consistent with the practicability of carrying the device at all times so that it is always available for use during escape. It consists of a small filter element, a mouth piece, a nose clip and means of carrying conveniently on the body. The filter elements are similar to chemical cartridge. The extent of protection afforded is between that provided by canister gas mask and that provided by a chemical cartridge respirator.

Mechanical filter respirators
These remove particulate matter from the inspired air which passes through a filter. These filters may be of the single use or re-usable type. If these respirators are used in heavy concentration of particulate matter, the filter will be clogged with dust particulate too quickly and they may have to be replaced every now and then. Micro filter are special filters designed to arrest ultra microscopic size of dust particles and these are use where extremely fine dusts are encountered.

Combination of chemical and mechanical filter respirators
They remove toxic gases and vapours and particulate matter from inspired air. Example of their use is in spray painting work.
6.12 Selection of Respirator
The following factors should be considered while selecting a respirator:
- Nature of the hazard
- Severity of the hazard
- Type of contaminant
- Concentration of the contaminant
- Period for which respiratory protection must be provided.
- Location of the contaminated area with respect to a source of respirable air
- Expected activity of the wearer
- Operating characteristic and limitations of the available respirator

6.13 Care of Respirators
Instruction in the use of respirators among other things should include the following aspects:
- Why it is to be used.
- How it is to be used.
- Checking that it is in good operating condition.
- Fitting of respirator.
- Proper use and maintenance of the respirator.

A respirator testing laboratory
- Respiratory protective equipment test facilities are available at central labour institute, SION, Mumbai – 400022.
- Realising the needs and problems faced by the manufacturers in the country, a respirator testing laboratory has been established in the Central Labour Institute at Mumbai under the Ministry of Labour.
- This laboratory undertakes the testing of indigenously manufactured respiratory protective devices under prescribed test conditions.
- It is equipped with facilities for testing breathing resistance; face-piece leakage, exhalation valve leakage, filtration efficiency against a standard dust and cartridges against known concentration of specific gases or vapour.
- The performance standards suggested in the USA are generally followed.
Summary

- Personal protective equipment (PPE) refers to the respiratory equipment, garments, and barrier materials used to protect rescuers and medical personnel from exposure to biological, chemical, and radioactive hazards.
- In the Factories Act 1948, there are specific provisions for providing the personal protective equipment to the worker who are exposed to unsafe and unhealthy environment.
- The most common routes of exposure to the hazards include inhalation (breathing, from the air), skin contact, and ingestion (eating or drinking).
- The Occupational Safety and Health Administration (OSHA) requires PPE to be provided, used, and maintained in a sanitary and reliable condition wherever hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants are encountered in a manner capable of causing injury or illness through absorption, inhalation, or physical contact.
- It is the responsibility of an employee to use PPE in accordance with training and to report any loss or defect immediately.
- Degree of the hazards and nature of activities of the user concerned are important consideration in the selection of safety and clothing.

References


Recommended Reading

- The American Conference of Governmental Industrial Hygienists (ACGIH). Threshold Limit Values. Cincinnati: ACGIH, published annually.
## Self Assessment

**1.** PPE stands for ______________________________.
   a. Personal protective equipment
   b. Personal protective engine
   c. Private protective equipment
   d. Physical protection equipment

**2.** Which of the following statements is true?
   a. PPE protects from the exposure to biological hazards.
   b. PPE protects from the exposure to biological, chemical, and radioactive hazards.
   c. PPE protects from the exposure to physical, chemical, and radioactive hazards.
   d. PPE protects from the exposure to radioactive hazards.

**3.** Which of the following statements is true?
   a. PPE are useful only in sports.
   b. PPE are useful only in industries.
   c. PPE are useful in industries and sports.
   d. PPE are useful in everyday routine.

**4.** Which of the following statements is true?
   a. The use of any type of personal protection equipment is user friendly.
   b. The use of any type of personal protection equipment requires adequate training.
   c. PPE is very easy to put on.
   d. Movement is very easy after wearing the PPE.

**5.** __________ can only be used for the period of time allowed by the air in the tank.
   a. APR
   b. PPE
   c. CPC
   d. SCBA

**6.** __________ only can be used in environments in which the outside air provides sufficient oxygen.
   a. APR
   b. PPE
   c. CPC
   d. SCBA

**7.** Equipments for head protection are __________.
   a. hat and helmets
   b. face shields
   c. mittens
   d. waistband
8. Which of the following statements is true?
   a. Respiratory equipment should be provided to the workers exposed to possible hazard.
   b. Processes, which present hazards of exposure to harmful substances, should, if possible, be open.
   c. A supply of appropriate protective equipment should be limited for use.
   d. Respiratory protective equipment should be considered a very first resort.

9. Selection of the right type of respiratory protective equipment depends upon ________.
   a. health of employer
   b. age of employer
   c. type of hazard
   d. timing of work

10. A person breathing air with oxygen content of _________ may exhibit symptoms ranging from increased rate of breathing, acceleration of pulse rate to unconsciousness and death.
    a. 25% or more
    b. 16% or less
    c. 16% or more
    d. 22%
Chapter VII

Occupational Lung Diseases

**Aim**

The aim of this chapter is to:

- classify the various types of occupational lung diseases
- explain the prognosis of various lung diseases
- define various methods to measure airborne particulates

**Objectives**

The objectives of this chapter are to:

- define classification of pneumoconiosis
- explain colorimetric-type devices
- describe detector tube systems

**Learning outcome**

At the end of this chapter, you will be able to:

- explain colorimetric tape samplers
- define dust retention without fibrosis
- understand cascade impactors
7.1 Introduction

Repeated and long-term exposure to certain irritants on the job can lead to an array of lung diseases (pneumoconiosis) that may have lasting effects, even after exposure ceases. Certain occupations, because of the nature of their location, work, and environment, are more at risk for occupational lung diseases than others. Contrary to a popular misconception, coal miners are not the only ones at risk for occupational lung diseases. For instance, working in a car garage or textile factory can expose a person to hazardous chemicals, dusts, and fibers that may lead to a lifetime of lung problems if not properly diagnosed and treated.

Common occupational lung diseases and their causes

- Asbestosis, caused by exposure to asbestos particles. Often found among people who worked in shipyards, asbestos mines, and factories that refined or used asbestos to manufacture products.
- Black lung (Coalworker’s pneumoconiosis) which affects coal workers
- Chronic Beryllium disease (CBD), which affects workers in a variety of metallurgical occupations
- Byssinosis (brown lung disease), often occurs in cotton and textile workers when bacteria released from cotton or other materials is inhaled and grows with the lungs. This is often associated with poor ventilation systems.
- Hypersensitivity pneumonitis, this can affect people who work in office buildings whose air-conditioning systems are contaminated by certain fungi and bacteria.
- Occupational asthma, can affect people who work with a variety of materials. This includes animals (dander), carbamates (urethanes), dyes, epoxy resins and enzymes used in detergent, leather goods, latex, and automotive paints
- Silicosis often developed by people who worked with clay, sand and stone dust including miners, stone cutters and sandblasters.

7.2 Classification of Pneumoconiosis

It can be classified by cause into those due to inhalation of inorganic dusts and those due to organic dusts. It is important to differentiate those dusts (such as asbestos and silica) which provoke a fibrotic reaction in the lung, from those, which are retained without provoking such a reaction (such as tin iron). Those which do provoke an inflammatory fibroic reaction in the lung can conveniently be divided according to the pattern of the reaction.

<table>
<thead>
<tr>
<th>Effects on lungs</th>
<th>Inorganic Dusts</th>
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<tbody>
<tr>
<td>Retention</td>
<td>Iron (siderosis)</td>
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<td></td>
<td>Tin (stansosis)</td>
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<td></td>
<td>barium (baritosis)</td>
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<td>Granulomatous (simple workers</td>
<td>Beryllium</td>
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<td>pneu-reaction moconiosis)</td>
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<tr>
<td>Fibrosis: nodular diffuse massive</td>
<td>Talc</td>
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<tr>
<td></td>
<td>Silica</td>
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<td></td>
<td>Asbestos</td>
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<td></td>
<td>Beryllium</td>
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<td></td>
<td>Coal</td>
</tr>
<tr>
<td>Caplan nodules</td>
<td>Silica</td>
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<tr>
<td></td>
<td>Coal</td>
</tr>
<tr>
<td></td>
<td><strong>Organic Dust</strong></td>
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<tr>
<td>Extrinsic allergic alveolitis</td>
<td>M. Faeni (Farmer’s lung)</td>
</tr>
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<td></td>
<td>T. Sacchari (bagassosis)</td>
</tr>
<tr>
<td>Acute granulomatus</td>
<td>Clavatus (malt worker’s lung)</td>
</tr>
</tbody>
</table>

Table 7.1 Classification of pneumoconiosis
7.3 Symptoms of Occupational Lung Disease
The following are the most common symptoms of lung diseases, regardless of the cause. However, each individual may experience symptoms differently. Symptoms may include:

- Coughing
- shortness of breath
- chest pain
- chest tightness
- abnormal breathing pattern

The symptoms of occupational lung diseases may resemble other medical conditions or problems so it is recommended to consult your physician for a diagnosis.

7.4 Diagnosis
Occupational lung diseases, like other lung diseases, usually require an initial chest x-ray for preliminary diagnosis. In addition, various tests may be performed to determine the type and severity of the lung disease, including:

- Pulmonary function tests - diagnostic tests that help to measure the lungs’ ability to exchange oxygen and carbon dioxide appropriately. The tests are usually performed with special machines into which the person must breathe.
- microscopic examination of tissue, cells, and fluids from the lungs
- biochemical and cellular studies of lung fluids
- measurement of respiratory or gas exchange functions
- examination of airway or bronchial activity

7.5 Difference between Inorganic and Organic Dust
Particles in the air may cause lung problems. Often called particulate matter (PM), particles can consist of a combination of dust, pollens, molds, dirt, soil, ashes, and soot. Particulate matter in the air comes from many sources, such as factories, smokestacks, exhaust, fires, mining, construction, and agriculture. The finer the particles are, the more damage they can do to the lungs, because they are easily inhaled deep into the lungs, where they are absorbed into the body. Inorganic refers to any substances that do not contain carbon, excluding certain simple carbon oxides, such as carbon monoxide and carbon dioxide. Organic refers to any substances that do contain carbon, excluding simple carbon oxides, sulfides, and metal carbonates.

7.6 Patterns of Abnormality seen on Chest Radiographs in Pneumoconiosis Opacities

**Small rounded**

Occupational causes: Siderosis, stannosis, baritosis, coal worker’s pneumoconiosis, silicosis, talc pneumoconiosis, acute beryllium diseases, acute extrinsic allergic alveolitis, (e.g. farmer’s lung).
Non-occupational causes: Sarcoidosis, tuberculosis, acute extrinsic alveolitis, (e.g. bird fancier’s lung), pulmonary metastases (e.g. from breast and thyroid cancers) healed chicken pox, pneumonia, haemosiderosis, histoplasmosia.

**Massive lesions**

Occupational causes: Asbestosis, Talc pneumoconiosis
Non-occupational causes: Heart failure, cryptogenic fibrosing alveolities, fibrosing alveolities, fibrosing alveolities, associated with: Rheumatoid diseases, scleroderma, SLE, sjogrenn’s syndrome.

**Small rounded with large opacities** (the quality or state of a body that makes it impervious to the rays of light)

Occupational causes: Coal worker’s pneumoconiosis complicated by: Progressive massive fibrosis, calpan’s syndrome, silicosis, conglomerate silicosis, Pulmonary tuberculosis, Calpan’s syndrome.
Non occupational causes: Lung Cancer/ Tuberculosis.
Small rounded which may progress to upper lobe fibrosis
Occupational causes: Extrinsic allergic alveolitis (due to occupational causes), Beryllium disease, Silicosis complicated by tuberculosis. Mixed dust fibrosis (which may or may not be complicated tuberculosis).
Non-occupational causes: Sarcoïdosis, extrinsic allergic alveolitis (due to non-occupational causes).

7.7 Dust Retention without Fibrosis
Dust: Metallic iron or iron oxide, dust or fume (siderosis)

Circumstances of exposure
- Mining of iron are (Haematite, Magnetite and Limonite)
- Fettling (i.e. removal of burnt – on moulding sand with pneumatic hammers from iron castings) in iron foundaries.
- Electric ore and oxyacetylene welding (welding temperatures liberate iron oxide fume – heavy exposure occurs particularly in enclosed poorly ventilation spaces)
- Boiler scaling (cleaning of coal fired boilers which contain a high concentration of iron and carbon as well as quartz.)
- Silver polishing with iron oxide power (jeweller’s rouge). Metallic bagging of tin ore, tin smelting, tin oxide, mining barites fume or bagging dry barites (stannosis) Barium sulphate (barytes), baritosis.

It is important to appreciate that miners of these materials may also be exposed to a significant silica hazard, which can produce similar changes on the chest radiograph. Furthermore, haematite miners, fettlers, welders and boiler scalers may also be exposed to silica, which can cause a mixed dust fibrosis.

7.8 Pneumoconiosis, Silicosis or Fibrosis caused by Small Rounded Opacities of Coal Dusts
Coal workers pneumoconiosis (CWP) and silicosis both produce small rounded opacities on the chest radiograph (simple CWP and simple silicosis). Both may also be complicated by the development of large opacities, in coal worker due to either to progressive massive fibrosis of Caplan’s syndrome, and in silicosis to conglomerate silicosis, pulmonary TB or Caplan’s syndrome. Commercial Talc containing high silica content may also produce small rounded opacities on the chest radiograph which may be complicated by the development of large opacities.

Coal worker’s pneumoconiosis
- It is caused by the inhalation of coal dust. Those exposed to the highest concentrations have been men working underground, particularly at the coal face.
- However, men in other underground job, such as those transporting coal from the face to the pit shaft and those making and repairing underground roadways are also exposed to coal dust.
- Surface workers such as those sorting and grading the coal on the ‘screens’ are less exposed. Coal trimmers who loaded and distributed coal in the holds of collier ships were exposed to high dust concentrations, but this work is now done mechanically.
- Pulmonary disease attributable to coal dust exposure is detected and followed by the changes produced on the chest radiograph.
- The different diseases due to coal dust exposure: simple CWP, progressive massive fibrosis and Caplan’s syndrome are distinguished and classified according to the radiographic appearances.

Silicosis
Silicosis is caused by the inhalation of respirable dust which contains more than about 10% free silica (silicon dioxide). Silica occurs in nature in forms of quartz, cristobalite and tridymite. Quartz is the commonest mineral and is a constitution of many rocks, including granite, sandstone and slate, but not of chalk or limestone. Silica is extremely toxic to alveolar macrophages destroying those which phagocytose it, initiating a bifrotic reaction. Unlike asbestos, which causes a diffuse fibrosis in alveolar walls, silica provokes a discrete nodular fibrosis. The collagen fibres in a silicotic nodule are arranged in a characteristic concentric pattern (‘whorled’ or ‘onion skin’ fibrosis), which allows them to be identified in histological sections of the lung. Following are types of Silicosis.
Simple silicosis
- Simple silicosis is diagnosed by the presence of small rounded opacities on the chest radiograph.
- Initially these develop in the upper lobes but may progress, even in the absence of further exposure, to involve the whole lung.
- The opacities are classified in the same way as in simple CWP according to their profusion and size.
- The extent of the radiographic abnormalities in simple silicosis is related to total dust exposure.
- Calcification of the opacities of hilar glands which gives them an ‘egg shell’ appearance on the chest radiograph.
- The speed of appearance and progression of these small rounded opacities depends primarily upon the amount of respirable dust inhaled.

Complicated silicosis
Simple silicosis may be complicated by massive fibrotic lesions (conglomerate silicosis), tuberculosis (silicotuberculosis and by Caplan’s syndrome)

Acute silicoproteinosis
- Acute silicoproteinosis is an unusual reaction to silica exposure.
- It follows very heavy exposure to respirable silicas as may occur in sandblasting or in tunneling, which may develop within six months of first exposure, are of fever, weight loss, cough and increasingly severe breathlessness.
- The appearances of the chest radiograph are very similar to those of acute pulmonary oedema and alveolar proteinosis, with perihilar confluent “bat’s wing” shadowing, often showing air bronchograms.
- The disease progresses rapidly with those affected dying from intractable respiratory failure.

Mixed dust fibrosis
- The term ‘mixed dust fibrosis’ is given to the pulmonary disease caused by the inhalation of Silica dust simultaneously with another non-fibrogenic dust.
- Non-fibrogenic dust inhaled with Silica appears to modify the fibrogenicity of the inhaled silica. When the proportion of free silica to the non-fibrogenic dust is low, the characteristic nodular fibrosis of silicosis does not occur, instead irregular stellate fibrous lesions are produced.
- Complicating massive fibrosis can also occur and tuberculosis occurs as frequently as in silicosis.
- Mixed dust fibrosis has occurred most commonly in occupations where there is a mixed exposure to silica and iron, such as in Haematite miners, iron foundry workers, electric arc and oxyacetylene welders in iron foundries and in fettlers and boiler scalers.
- Increasingly severe breathlessness on exertion, together with a cough productive of reddish – brown sputum develops particularly in those with massive lesions. Respiratory failure with pulmonary hypertension can develop in those with massive fibrosis.

7.9 Dust cause Small Irregular Opacities
Asbestosis
- Asbestosis is diffuse pulmonary fibrosis caused by inhalation of asbestos fibres. Its frequency in those occupationally exposed is related to both the degree and duration of exposure.
- Asbestos fibres are ingested by alveolar macrophages and transported centrally to the alveoli within the walls of the first and second order respiratory bronchioles, where they provoke a local fibrotic reaction.
- This spread peripherally to involve the whole acinus producing a diffuse interstitial fibrosis. The fibrosis commences subpleurally in the lower lobes and spreads both within the lobes and to involve the middle lobes and lingual, the lower lobes tending to remain the most severely affected.
• Asbestosis causes breathlessness on exertion, slowly increasing in severity with progression of the disease. Clubbing of fingers and toe nails is frequently present, dependant and inspiratory crackles, not altered by coughing are usually audible at the base of the lungs.

• The characteristic abnormalities seen on the radiograph of small irregular opacities predominantly in the lower zones. These changes may be classified according to their profusion and size by the ILOU classification. With progression of the disease these small irregular opacities become more profuse, together with gradual plaques or by diffuse pleural thickening. Irregular opacities on the chest radiograph which predominantly affect the middle and upper zones of the lungs are rarely due to asbestosis.

• The diagnosis of asbestosis is made on finding the appropriate clinical physiological and radiographic features of the disease in a person who has substantial occupational asbestos exposure.

• Exposure to asbestos can cause one or more of several diseases of the lungs or pleura:
  • Benign pleural diseases, diffuse pleural thickening, pleural plaques, pleural effusion
  • Malignant mesothelioma of pleura (end of peritoneum)
  • Diffuse pulmonary fibrosis (asbestosis)
  • Lung cancer

Talc pneumoconiosis

• Talc is a hydrated magnesium silicate, which microscopically appears as flat polygonal plates. Other minerals, particularly tremolite and anthophyllite asbestos and quartz are found in the rock from which it is mined and commercial talc contains variable amounts of these other minerals.

• Talc is used industrially as paint filler, as a constituent of ceramics and roofing materials, in the rubber industry to prevent adhesion of rubber in moulds and to aid extrusion, and also in cosmetic powders.

• Talc pneumoconiosis has been described in talc miners and millers, and in some commercial users, such as the rubber industry.

• Exposure to commercial talc may involve exposure not only to talc but also to tremolite and anthophyllite asbestos and to quartz.

• Three separate types of histological reaction may occur in the lungs
  • the dominant pattern depending on the composition of inhaled talc,
  • ill defined nodular lesions, which may show incomplete whirling due to quartz with talc,
  • diffuse intestinal fibrosis produced by the asbestos, spreading peripherally from the respiratory bronchioles, resembling asbestosis, foreign body granulomata probably due to the talc alone.

• Breathlessness on exertion is associated with either the diffuse fibrotic pattern of disease or in nodular form when massive lesions have developed. Finger clubbing and basal and basal end inspiratory crackles can be found in the diffuse fibrotic type of disease.

• Talc pneumoconiosis generally progresses slowly and rarely shortens life, although premature death may occur with widespread massive lesions and diffuse pulmonary fibrosis.

7.10 Extrinsic Allergic Alveolitis

Extrinsic allergic alveolitis describes a group of diseases characterised by a granulomatous inflammatory reaction, which may progress to fibrosis, in alveolar walls and respiratory bronchioles. It is caused by a local hypersensitivity reaction to inhaled organic dusts. The disease has three distinguished modes of presentation which are related primarily to the pattern and intensity of exposure to the causal antigen, acute, sub acute and chronic.

• Acute allergic alveolitis follow intermittent heavy exposure, recurrent episodes of breathlessness with fever and ‘flu-like symptoms, such as headache, shivering and myalgia often with associated weight loss, develop some four to eight hours after exposure and persists, in the absence of further exposure, for some seven to ten days. Scattered and inspiratory crackles may be heard on examination of the chest. Small ill – defined rounded opacities are seen on the chest radiograph often in all three lung zones. These usually resolve spontaneously in the absence of further exposure within about four to six weeks, but can persist.
Continuous heavy exposure can lead to sub acute allergic alveolitis. Instead of recurrent episodes following intermittent exposure, the symptoms experienced are increasingly severe breathlessness, malaise and weight loss with persistent fever. The abnormalities on examination of the chest and the chest radiograph are similar to the acute disease, although the shadows on the chest radiograph may be larger or become confluent. In both forms of the disease the changes in lung function test measurements are the same, a restrictive ventilatory defect with a decrease in the carbon monoxide gas transfer test. With evidence of further exposure to the causal antigen both acute and subacute extrinsic allergic alveolitis are usually largely or completely reversible diseases.

With continued antigen exposure chronic irreversible changes in lung function occur, due to the development of pulmonary fibrosis. The disease may also present at this chronic stage in those with light exposure to the causal antigen of long duration. Typically, such patients complain of increasing limitation of activities from breathlessness, usually without associated constitutional symptoms, apart from weight loss. Scattered and inspiratory crackles may be heard on examination of the chest. Small rounded opacities on the chest radiograph are associated with contraction and destruction of the lobes, often with cyst formation. Lung function test measurements typically show a restrictive ventilatory defect with impairment of carbon monoxide gas transfer. Patients with the disease may also have evidence coexisting airway narrowings, which may become sequence of the disease or due to unrelated causes, such as cigarette smoking.

The diagnosis of extrinsic allergic alveolitis is based upon recognition of the appropriate clinical radiographic and functional features of the disease, identification of a potential source of antigen in the patient’s home or working environment and demonstration of precipitating antibodies in the serum to the causal antigen.

Farmer’s lung

- The most important occupational cause of extrinsic allergic alveolitis is farmers’ lung, which may be present in any of the three ways described before.
- It is caused by an allergic reaction to Micropolyspera faeni which grow in mouldy hay, straw or cereal grain in which the water content exceeds 35% and the temperature is 50\(^0\) or more.
- These growth requirements are fulfilled when organic vegetable matter is harvested in poor conditions and stored damp, which allows moulding with self-heating to occur.
- Exposure to M. Faeni occurs when bales of mouldy hay or straw are opened for animal feeding and when mouldy grain is moved or thrushed, particularly when such operations are carried out in a ventilated barn or sheds.

Humidifier fever

- A similar disease which has been called ‘humidifier fever is due to a reaction to micro-organisms growing in water reservoir tanks.
- It occurs in those working in factories where water is required for air humidification, or for pressure generation.
- Those affected have symptoms typically of recurrent attacks of acute allergic alveolitis, breathlessness associated with fever, shivering, myalgia and headache about hours after starting work.
- Usually symptoms occur on the first day back at work after an absence over a weekend or in holiday and improve spontaneously over the following 12 to 36 hour despite continuing exposure at work during week.
- Lung function measurements made before and after a working day in which symptoms occur, show the development of a restrictive ventilatory defect and of decrease in the carbon monoxide gas transfer test.
- These abnormalities improve spontaneously during the working week and recur with the return of symptoms, on returning to work after an absence.
- The chest radiograph in those with humidifier fever is normal during acute attacks. Furthermore, despite recurrent attacks in some over periods of several years, measurements of lung functions shows irreversible changes and also abnormalities do not develop on the chest radiograph. Lung biopsy findings have not been reported.
**Beryllium disease**

- Exposure to high concentrations of these materials can cause an acute inflammatory reaction which is confined to the respiratory tract and which in these most severely affected causes pulmonary oedema.
- This is acute beryllium disease, where not fatal, it is usually followed by complete recovery, although chronic beryllium disease has been reported in a small proportion of those who recover.
- Chronic Beryllium disease may follow acute beryllium disease, but more usually occurs without a preceding acute illness, in those exposed over a long period to relatively low concentrations of dust or fumes.
- Beryllium is extracted from the ore beryl, an aluminium beryllium silicate which is mined in South Africa, the United States, South America and India.
- Beryllium disease, both acute and chronic, occurs in those extracting beryllium from the ore in which beryllium sulphate, beryllium fluorides and beryllium hydroxide are produced. Beryllium oxide is derived from the hydroxide by calcination.
- Respiratory disease is the most common mode of presentations of chronic beryllium disease. Symptoms may develop within months to several years of exposure usually within five years of last exposure, but in some 10% of symptoms have developed after an interval of more than ten years from last exposure.
- Patients usually present with increasing exertional dyspnoea, or with dry unproductive cough accompanied by lethargy and considerable weight loss. With greatly improved industrial hygiene, exposure to beryllium in those with disease has been less severe and such features are now unusual.
- Furthermore, with regular screening of those working with Beryllium, cases of the disease may be identified by finding abnormalities on a chest radiograph in those without respiratory symptoms, scattered respiratory crackles may be heard on examination of the chest, but frequently no abnormal physical signs are present.

### 7.11 Tests of Pulmonary Function

#### Ventilation

The tests of ventilatory function have certain limitations

- They require maximal voluntary effort by the patient, who for various reasons may be unable or reluctant to perform the tests as well as ventilatory capacity permits.
- The results of these tests vary considerably among the normal people of the same sex, age and height.
- Infrequently, significant impairment of respiratory function can exist even though the patient can perform the tests of ventilatory function normally, that is, the bellows action of the lungs and thorax is normal, but there are abnormalities of pulmonary circulation and/or gas exchange that give rise to the impairment and necessitate other procedures for evaluation.

**Characteristics of the test**

- Various types of apparatus are available that give a permanent record and that readily permit measurement of the FEV1 and the FVC and determination of the maximal voluntary ventilation (MVV).
- These tests can be understood by patients after a short explanation and instruction period, but most patients will need to be encouraged to put forth their best effort.
- The FEV1 and FVC should each be administered three times, with the best test result determined as most representative of the patient’s ability.
- The test should not be considered valid unless the best two curves agree within five percent.
- The MVV is a fatiguing test, requiring considerable muscular effort on the part of the patient who must breathe as deeply and as rapidly as possible for 10-15 sec, and for this reason the better of the two attempts (rather than three) should be accepted as morerepairment of patient’s ability.
- The degree of permanent impairment of patients known to have severe impairment of ventilation can usually be established without the MVV test.
If the forced expiratory volume test is interpreted as showing airflow obstruction, the test might be repeated 5-10 min after the patient has inhaled a nebulised bronchodilator. If there is at least 15 percent improvement in the performance of the incidentally, the presumed efficiency of bronchodilator therapy are established. However, the best results of tests before bronchodilator should be used in determining the degree of impairment.

Results of tests of ventilatory function should be expressed in terms of litres or litres per minute and also as percentage of the predicted normal. The FVC as a percentage of the predicted normal is taken as a measure of restriction impairment, but the ratio of actual FEV₁ to actual FVC is considered a better measure of obstructive impairment than is value of measured FEV₁ as a percentage of predicted FEV₁.

Quantitative exercise capacity measurements can be done using a treadmill or stationary bicycle but such testing can be hazardous to individuals in poor health.

Determinations of partial pressures of oxygen and carbon dioxide in arterial blood, particularly before and after exercise, can be useful in certain cases. These measurements require arterial puncture, thus, are not suitable for routine evaluation.

### 7.12 Sampling and Counting of Dust

There are various methods available for counting of airborne particulates, collected on filters, electronic precipitators, cascade impactors, impingers and elutriators.

**Filters**

- The most common collection method for airborne particulates is a filter.
- They are easy to use and are available in a wide variety of synthetic materials and pore sizes.
- Filter materials include glass fibre, mixed fibre, plastic fibre, membrane and nucleopore. The selection of a filter depends on cost, availability, collection efficiency, requirements of the analytical procedure, and the ability of the filter to retain its filtering properties and physical integrity under sampling conditions.
- Mixed – fibre filters for example, are used when a simple gravimetric analysis is to be performed.

**Cyclones**

- It is sometimes necessary to measure only the respirable fraction of dust.
- These are particles that are 10 μm or less in size and penetrate deep into the lungs. Therefore, collection of respirable dust provides the best estimate of a health hazard caused by the inhalation of insoluble dust particles.
- A 10-cm cyclone with a pre-weighed filter is used to collect personal respirable dust samples.
- The cyclone and filter assembly is usually attached to the workers lapel. Air is drawn into the cyclone through a small orifice. The air is then accelerated and whirled causing the heavier (larger) particles to be thrown out to the edge of the airstream and dropped to a removal section at the bottom of the cyclone. The respirable particles remain in the center stream and are drawn up and collected on the filter.
- Gravimetric procedures require careful pre-weighing and post-weighing of the filter. Weighing errors are usually the result of moisture, improper handling, or poor technique. Even filters described as non-hygroscopic can accumulate some moisture. Special techniques are required in handling filters before and during weighing. At a minimum, procedures include:
  - The same person should weigh the filter before and after sampling using the same balance.
  - Filters should never be touched with hands, because moisture and oil from the skin will cause weighing errors. Use tweezers or tongs.
  - Before initial (before exposure) weighing, all filters should be stored in a desiccant cabinet to remove any moisture.
  - For sampling, remove filters from the desiccant cabinet one at a time; weigh one at a time.
  - Use a balance with a drying cylinder to prevent moisture errors during weighing.
  - Record pre-exposed weight of the filter correlating the weight to the filter number. Place filter in its holder (still using tweezers or tongs), and seal the holder.
After sampling, remove the cover from the filter holder and place the exposed filter in the desiccant cabinet for a period of 16-24 hours to remove excess moisture; filter must be free from the backup disk before drying.

After drying, filters should be removed from the drying cabinet one at a time (using tweezers) and placed on the balance for weighing.

Record the final weight.

Take care not to damage the filter after it has been exposed, because any loss of filter substance will result in erroneous weight calculation.

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**Table 7.2 Sampling techniques for collection of airborne particulates**

**Electrostatic Precipitator**

An electrostatic precipitator passes a relatively high airflow through a high – voltage electrical field. It consists of a grounded metal tube that serves as a collecting electrode. Particulates passing through the electrical field are attracted to the cylinder wall where they are collected.

Such a precipitator can be used to collect air-samples for microscopic or chemical analysis. They are particularly well suited to collect particles of submicron size, such as metal fumes. But these units cannot be used in areas containing combustibles or in areas where sources of ignition are prohibited.

**Cascade impactors**

Cascade impactors can be used to determine the particle size distribution of an air sample. Their operation is based on the principle that when a high velocity dust-laden air stream strikes a flat surface at a 90 – degree angle, the sudden change in direction and momentum causes the dust to separate from the air and impact on the deflecting obstacle.

**Impinger**

An impinger is an apparatus through which air is drawn at high velocity and impinged onto a plate that is immersed in a liquid collection medium. As the particles are impinged on the plate, they lose their high velocity and become wetted by the liquid. The particles trapped in the liquid are counted using a microscope. Impingers are seldom used today for particulate air – sampling. Elutriators are used in the front of a sampling train to remove coarse particulate matter enabling a filter or other collection device to collect only smaller size particles.
**Integrated air sampling**

Integrated air-sampling is used to determine a worker’s 8-hour TWA exposure to a toxic chemical. It is also used if the concentration of the toxic material varies significantly during the work shift or if a large sample volume is necessary to satisfy the sensitivity requirements of the analytical method.

**Instrumentation**

The entire array of equipment used to perform an air-sampling task is contained in the air-sampling train. An air-sampling train consists of an air-inlet orifice, collection media, airflow meter, flow-rate control valve, and suction pump.

**Air-sampling pumps**

A critical component of the air-sampling system is the air-sampling pump. The proper selection and calibration of that pump is a critical element of the sampling process. A pump must be selected, based on the desired sampling flow-rate, ease of servicing and calibration, and suitability in a hazardous environment, among other factors. The primary determinant is the desired flow-rate. Personal, battery-powered air-sampling pumps can be classified into these basic categories.

**Rotameters**

Rotameters are commonly attached to high-flow sampling pumps. They consist of a “float” or ball that is free to move up or down within a vertical tapered tube which is larger at the top than the bottom. As air is pumped into the bottom of the tube, the ball will rise until an equilibrium is reached between the weight of the ball and the force exerted on the ball by the pressure of air flowing through the annular area between the ball and the wall of the tube. The height of the ball is measured against a numerical scale attached to the tube and is an indirect measure of flow-rate. The ball is commonly read at the point of maximum diameter (ball centre).

**Critical orifice**

Some high and low-flow pumps use critical or limiting orifices to regulate airflow–rate. A critical orifice is a precision drilled hole in a metal plate through which the air-stream being sampled is directed. When certain critical parameters are met, the flow-rate through the orifice remains constant despite changed in inlet conditions (e.g., clogged filter).

**Constant – flow samplers**

Constant –flow samplers are designed to overcome the flow-rate variation problems inherent in many sampling situations. Increased collection media resistance, such as a filter loaded with dust or a crimped hose can effect the flow-rate. These pumps have sophisticated flow-rate sensors with feedback mechanisms, which permit maintenance of the preset flow-rate during the sampling period. They are available on both high – and low sampling pumps.

**Stroke counters**

Some low-flow sampling pumps have stroke counters. Stroke counters provide an indirect measurement of sample volume on pumps with a piston-action motor. Each stroke of the piston is recorded on a dial and related to the amount of air moved by the pump during that piston stroke.

**Calibration**

Calibration of air-sampling pumps is an integral part of the accurate measurement of airflow-rate and volume. There are two categories of calibration methods, primary methods are generally direct measurements of volume on the basis of the physical dimensions of an enclosed space. Secondary methods must be calibrated themselves against a primary standard and have been shown to maintain their accuracy with use.
Primary standards-soap-bubble meters
A soap-bubble meter is considered a primary method of calibration and is commonly used to calibrate high- and low-flow air–sampling pumps (method accuracy can be within +_ 1 percent). It consists of an upturned laboratory burette (a 1,000-mL burette is used to calibrate high–flow pumps, a 100 –mL burette is used to calibrate low-flow pumps), a ring stand and clamp, tubing, selected collection media, and the pump. The selected collection media to be used in air-sampling must be used during the calibration of the pump. Electronic bubble flow meters for pump calibration are available.

Secondary standards
Though they rely on periodic recalibration against primary standards, secondary standards can provide an accuracy of +_ 1.0 percent or better. Secondary standards include wet-test meters, dry-gas meters, and precision rotameters. Wet–test meter. A typical wet-test meter is a partitioned drum, which is half submerged in a liquid (usually water), with openings in the center and periphery of each radial chamber. Air or gas enters at the center and flows into one compartment causing it to rise, thereby causing rotation. The number of revolutions is indicated on a dial on the face of the meter.

Because liquid is being displaced by air, the volume measured depends on the height of the fluid in the meter. A sight gauge for determining fluid height is provided along with a gas pressure gauge and a thermometer.
Summary

- The ultimate goal of the hazard evaluation process is to determine the exact amount of vapour or gaseous contaminants present in the work environment.
- Proper operation of various instrument used in hazard analysis is essential to ensure that the information obtained in air quality tests is accurate enough to provide a useful interpretation.
- Faulty operation of air sampling instruments can result in low readings; these can falsely indicate that no hazard is present when, in fact, dangerous conditions might exist.
- High instrument readings and the resulting implementation of a hazard control procedure may be instituted where none is needed.
- The type of information to be kept for the record includes instrument identification, temperature, humidity, trial run results, and final results.
- It is important that the operator thoroughly understands how to operate the instrument and be aware of the instrument’s intended use and the calibration procedures recommended by the manufacturer.

References

- APHA Intersociety Committee. Methods of air Sampling and can Public Health Association (APHA), 1977

Recommended Reading

**Self Assessment**

1. Repeated and long-term exposure to certain irritants on the job can lead to an array of ________________ that may have lasting effects, even after exposure ceases.
   a. lung diseases
   b. heart diseases
   c. skin diseases
   d. respiratory diseases

2. Which of the following statements is true?
   a. Certain occupations, because of the nature of their location, work, and environment, are safe for occupational lung diseases than others.
   b. Certain occupations, because of the nature of their location, work, and environment, are more at risk for occupational lung diseases than others.
   c. Repeated and long-term exposure to certain irritants on the job can lead to an array of skin diseases that may have lasting effects, even after exposure ceases.
   d. Coal miners are the only ones at risk for occupational lung diseases.

3. Which of the following statements is true?
   a. Working in a car garage or textile factory can expose a person to hazardous chemicals, dusts, and fibers that may lead to a lifetime of lung problems if not properly diagnosed and treated.
   b. Working in a car garage or textile factory can expose a person to hazardous situations that may lead to a lifetime of heart problems if not properly diagnosed and treated.
   c. Grey lung which affects coal workers.
   d. Black heart which affects coal workers.

4. ____________ can affect people who work in office buildings whose air-conditioning systems are contaminated by certain fungi and bacteria.
   a. Chronic Beryllium disease
   b. Byssinosis
   c. Hypersensitivity pneumonitis
   d. Black lung

5. Silicosis often developed by people who worked with ________________ including miners, stone cutters and sandblasters.
   a. asbestos
   b. fire
   c. fume
   d. clay

6. ____________ refers to any substances that do contain carbon, excluding simple carbon oxides, sulfides and metal carbonates.
   a. Inorganic
   b. Natural
   c. Chemical
   d. Organic
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7. __________ silicosis is diagnosed by the presence of small rounded opacities on the chest radiograph.
   a. Complicated
   b. Acute
   c. Simple
   d. Mixed

8. ‘Humidifier fever’ is due to a reaction to micro-organisms growing in ____________.
   a. water reservoir tanks
   b. septic tanks
   c. wet platforms
   d. sand

9. Which of the following statements is false?
   a. The most common collection method for airborne particulates is a filter.
   b. A 10-cm cyclone with a pre-weighed filter is used to collect personal respirable dust samples.
   c. Cascade impactors can be used to determine the particle size distribution of an air sample.
   d. A Rotameter is an apparatus through which air is drawn at high velocity and impinged onto a plate that is immersed in a liquid collection medium.

10. The ultimate goal of __________ evaluation process is to determine the exact amount of vapour or gaseous contaminates present in the work environment.
    a. risk
    b. problem
    c. hazard
    d. tension
Chapter VIII
Direct-Reading Gas and Vapour Monitors

Aim
The aim of this chapter is to:

- define colorimetric-type devices
- explain work physiology
- describe energy cost of work

Objectives
The objectives of this chapter are to:

- discuss matching people and their work
- explain capacity for physical work
- describe industrial audiometry

Learning outcome
At the end of this chapter, you will be able to:

- define audiometer
- explain bone conduction tests
- discuss types of hearing loss
8.1 Introduction

The concentration of gases and vapours in air can be determined readily with the use of direct-reading instruments. Sampling and analysis are carried out within the direct-reading instrument, and the required information can be read directly from a dial or indicator. Many direct reading instruments also feature digital displays that indicate the percentage of gas or of the vapour in air on a numerical digital scale.

An ideal direct-reading instrument should be capable of sampling air in the breathing zone of the worker and should specify the concentration of the substances under investigation—either as an instantaneous concentration or as a time-weighted average, depending on what information is required. Alternatively, the reading may be in terms of the percentages of an appropriate standard. In most cases, provision for keeping permanent records of the reading is essential. Direct reading instruments for vapours and gases include the following types.

8.2 Colorimetric Type Devices

- **Solid**: A known volume of air is passed through a small diameter glass tube containing porous solid granules impregnated with a reagent at a fixed rate. The reagent reacts with the vapour or gas contaminant and then changes colour. The degree or shade of colour or the length of the colour stain is related to the vapour or gas concentration.

- **Paper tape samplers**: A known volume of air is passed through paper impregnated with a reagent that reacts with vapour or gas and then changes colour. The degree of colour indicates vapour or gas concentration.

- **Liquid**: A known volume of air is bubbled through a liquid reagent that reacts with the vapour or gas. An indicator that changes colour when the reagent is consumed by a definite quantity of vapour or gas indicates the vapour or gas concentration in the sample.

**Thermal**

- **Conductivity**: The specific heat of the conductance of vapour or gas is measured to indicate the vapour or gas concentration.

- **Combustion**: The change in electrical resistance of the heated filament in a Wheatstone Bridge is caused by combustion of the vapour or gas. This change is measured to determine vapour or gas concentration.

- **Others**: Other measurements are based on potentiometric and coulometric study; the study of thin film electrochemical cells, infrared analysis, and polarographic study.

**Gas chromatography**

Various vapours and gases migrate differentially in a porous sorption medium contained in a column. Separated vapours and gases are later adsorbed and carried by an inert gas to a detector, such as an ionisation or electromagnetic device, for measurement.

8.3 Colorimetric Tape Samplers

**Principle of operation**

In modern devices, the chemically treated paper tape is drawn at a constant rate over the sampling orifice, and the contaminant reacts with the chemical to produce a stain. The intensity of the stain can be measured by a reflectometer, and the result can be displayed as a function of concentration.

- By directing light of equal intensity (from a common source through matched fiber optics) to both the top and bottom track and by mounting a set of matched photoelectric detectors at an angle of 45 degrees, the difference in reflected light can be measured. The system thereby compensates for slight tape variations.

- While the tape moves, a constant flow of the sample air is aspirated through the porous impregnated tape, which is controlled by means of the self-contained pump and flow controller.
8.4 Work Physiology

Work physiology means an aspect of industrial engineering that takes into account metabolic cost, measurement and prevention of work strain, and other ergonomic factors in the design of tasks and workplaces. People perform widely differing tasks in daily work situations. These tasks must be matched with human capabilities to avoid “under loading”, in which human capabilities are not utilised properly, as well as “overloading”, which may cause the employee to break down and suffer reduced performance capability or even permanent damage. Work physiologists evaluate the capacities and limitations of the worker for performing physical work; they also determine human tolerance to stresses produced by the physical environment.

8.5 Capacity for Physical Work

An individual’s physical tolerance of physical work is usually determined by the capacity of his or her respiratory and cardiovascular systems to deliver oxygen to the working muscles and to metabolise chemically stored energy.

- Maximum oxygen uptake is often used to describe the upper limit of this capacity. If a person is pushed beyond this limit in an emergency situation, the additional energy required is provided by anaerobic processes.
- The energy stores thus depleted (the oxygen debt) must be replenished following cessation of the emergency.
- Tolerance times for maximal efforts are measured in minutes or even in seconds for a sprint runner. In the modern industrial setting, maximal effort may be required for brief periods, such as when an employee must heave heavy loads onto a hand truck.
- However, during eight-hour shift, the average energy required usually falls well below human peak capacity.
- The biochemical processes that transform foodstuffs into energy available for work are quite complex; they involve a series of aerobic and anaerobic steps. Nevertheless, measurement of the volume of oxygen consumed provides a relatively simple overall index of energy consumption and hence of the energy demands of work.
- The ability to move oxygen from the air to the active muscle can be improved through physical training by up to 20 percent. Unfortunately, the efficiency with which humans convert oxygen to energy is quite low only about 5 percent or less of the maximal oxygen uptake capacity is converted to energy in daily activity.

8.6 Energy Cost of Work

Typically, the heaviest work that a young, fit man can sustain for prolonged periods is about 500 kcal/hr. Among the general population, this figure is somewhat lower 400-425 kcal/hr. These figures are equivalent to about 40 percent of the maximal uptake capability. Industrial jobs seldom demand such a high-energy expenditure over the course of a workday. Rest pauses, fetching tools, mopping the brow, and receiving instruction all tend to reduce the average energy expenditure considerably.

8.7 Heart Rate of Work

There is close interaction between human circulatory and metabolic systems. Nutrients and oxygen must be brought to the working muscles and metabolic by-products removed from them to ensure proper functioning.

- Therefore, heart rate (which is a primary indicator of circulatory functions) and oxygen consumption (representing the metabolic processes taking place in the body) have a linear and reliable relationship in the range between light and heavy work.
- The simplest technique for heart rate assessment is to palpate an artery, often in the wrist.
- The measurer counts the number of heartbeats over a given period of time such as 15 seconds and then calculates the average heart rate per minute.
- More refined methods utilise various plethysmographic techniques, which rely on the deformation of tissue due to changes that result when the imbedded blood vessels fill with blood.
- Use of heart rate measurement has one major advantage over oxygen measurement as an indicator of metabolic processes: heart rate reacts faster to work demands and therefore more easily indicates quick changes in body functions due to changes in work requirements.
8.8 Matching People and their Work

It is important to match human capabilities with the requirements of a given job. If the demands of the job equal the worker’s capabilities or exceed them, the person will be under much strain and may not be able to perform the task.

Hence, various stress tests, which are administered by a physician, have been developed to assess an individual’s capability to perform physically demanding work. Bicycle ergometers, treadmills, or steps are used to simulate stressful demands.

Work/Rest cycles

- In an event that demands more of the worker than can be sustained, rest pauses must be taken. A general principle governing the schedule of work/rest cycles is to break up excessively heavy work into bouts of work that are as short as is practical for the task at hand.
- Frequent short rest periods reduce cumulative fatigue better than a few long breaks. The worst procedure is to let the worker go home early, exhausted.
- A formula has been used to estimate the percentage of time that should be allotted to rest

\[
T_{rest} (%) = \frac{M_{max} - M}{M_{rest}} \times 100
\]

In the formula, \(T_{rest}\) is the percentage of rest time;
- \(M_{max}\) is the upper limit of the metabolic cost for sustained work;
- \(M\) is the metabolic cost of the task; and \(M_{rest}\) represents the resting (sitting) metabolism.
- For example, suppose that \(M_{max}\) equals 350 kcal/hr; an average value for \(M_{rest}\) is 100 kcal/hr. Then assume that the task requires 525 kcal/hr, which is obviously too high.

Apply these values to the formula as follows:

\[
\text{Rest time} = \frac{350 - 525}{100} \times 100 = -175 \times 100 = 41\% \quad 100 - 525 = 425
\]

Thus, rest pauses should be scheduled to last a total of 41 percent (24 min) of the hour.

8.9 Fatigue

Fatigue is an overexertion phenomenon that leads to a temporary decrease in physical performance. It is often associated with a buildup of lactic acid in the body, which can be metabolised to carbon dioxide and water during reduced activity, or rest.

- Subjective feelings of lowered motivation and deteriorated mental and physical activities may result from fatigue.
- Fatigue may occur together with monotony, a sensation associated with the lack of stimuli. Fatigue-induced low performance can be completely restored to its full level by rest.
- The subjective sensation of fatigue is feeling tired. When tired, a person has reduced capability and desire for either physical or mental work, and feels heavy and sluggish.
- The sensation of fatigue has a protective function similar to hunger and thirst. Feeling fatigues forces one to avoid further stress and allows recovery to take place.
- The most important factors that produce fatigue are: physical work intensity (static and dynamic work); illness, pain, lack of rest (sleep), poor eating habits; and psychological factors – worry, conflict, and possibly monotony.
- Hence, many different sources may be responsible for the sensation and the state of fatigue. In everyday experience, fatigue is often an accumulation of the effects stemming from various sources.
- It is evident that if the rhythm of life is to proceed normally, the possibilities of recovery should compensate for the strain which the organism undergoes daily.
• Severe, continuous daily fatigue eventually leads to chronic fatigue. Not only is the feeling of tiredness intensified and continuous after work, but occasionally a person feels tired before beginning work. The following signs signal chronic fatigue:
  • When physical complaints of this kind appear, the condition can be called “clinical fatigue”.
  • As a result of this condition, absences from work increase in frequency and duration, workers need longer rest periods, and they may show an increased susceptibility to illness.
  • It is often difficult to separate mental or emotional events from physical causes of fatigue. In clinical fatigue, one is hardly able to distinguish between cause and effect.
  • A negative attitude toward one’s work, superiors, or place or work can just as well be a cause of clinical fatigue as well as the result of it.

8.10 Noise Control Programmes

Noise is defined as unwanted sound at the wrong time and place. Degree of noise reduction required is determined by comparing the measured levels with acceptable noise levels. The next step is to consider various noise control measures, such as making alterations in engineering design, limiting the time of exposure, or using personal protective devices to achieve the desired level of reduction. Reduction of noise at source can be achieved by:

• Acoustic design
  • Decreasing energy which drives a vibrating system
  • Changing coupling between this energy and acoustical radiating system
  • Changing structure so that less sound is radiated
• Substitution with less noisy equipment;
• Changing in method of processing;
• Changes in path;
  • Increase distance between source and receiver
  • Acoustical treatment of ceiling, walls and floor to absorb sound and reduce reverberation
  • Enclosure of noise source
• Reduction of noise at receiver by:
  • personal protection
  • enclosures-isolating the worker
  • rotation of personnel to reduce exposure time
  • changing job schedules

Control measures

• Noise control can often be designed into equipment so that little or no compromise in the design goals is required.
• Engineering control of industrial noise problems requires the skill of individuals who are highly proficient in this field.
• Noise control strategies require careful objective analysis on both a practical and economic basis.
• Complete redesign requires that product and equipment designers immediately consider noise levels a primary product or equipment specification in the design of all new products.
• Full replacement of all products or equipment would eventually take place depending on the service life of each. Many designers feel this approach will minimise cost increases associated with noise control measures.
• Existing products or equipment modifications would require manufacturers to modify or replace existing products and equipment to lower the noise levels of noisy equipment.
• The existing equipment within any plant was probably selected because it was economical and efficient. However, careful acoustical design can result in quieter equipment that would even be more economical to operate than noisier equipment.
Examples of noise control measures applied at the source include: substitution of quieter machines, use of vibration – isolation mountings, and reduction of the external surface areas of the vibration resulting in sound vibration.

The proper use of machine mounting isolates the machines and reduces the transmission of vibrations to the floors and walls. Although substitution of less noisy machines may have limited application, there are certain areas in which substitution has a potentially wider application.

**8.11 Engineering**

When starting a noise reduction program, it is most desirable to apply engineering principles that are designed to reduce noise levels. The application of known noise control principles can usually reduce any noise to any desired degree. However, economical considerations, and / or operational necessities may make some applications impractical. Engineering controls are procedures other than administrative or personal protection procedures that reduce the sound level either at the source or within the hearing zone of the workers. The following are examples of engineering principles that can be applied to reduce noise levels.

**Maintenance:**
- replacement or adjustment of worn, loose, or unbalanced parts of machines
- lubrication of machine parts and use of cutting oils
- use of properly shaped and sharpened cutting tools

**Substitution of machines:**
- larger, slower machines for smaller, faster ones
- step dies for single – operation dies
- presses for hammers
- rotating shears for square shears
- hydraulic presses for mechanical presses
- belt drives for gears

**Substitution of processes:**
- compression riveting for impact riveting
- welding for riveting
- hot working for cold working
- pressing instead of rolling or forging

**Driving force of vibrating surfaces may be reduced by:**
- reducing the forces
- minimising rotational speed
- isolating

**Response of vibrating surfaces may be reduced by:**
- damping
- additional support
- increasing the stiffness of the material
- increasing the mass of vibrating members
- changing the size to change resonance frequency
The sound radiation from the vibrating surfaces can be reduced by:

- reducing the radiating area
- reducing overall size
- perforating surfaces

Sound transmission through solids can be reduced by using:

- flexible mountings
- flexible sections in pipe runs
- flexible – shaft couplings
- fabric sections in ducts
- resilient floorings

Sound produced by gas flow can be reduced by:

- using intake and exhaust mufflers
- using fan blades designed to reduce turbulence
- using large, low – speed fans instead of smaller, high speed fans
- reducing the velocity of fluid flow (air)
- increasing the cross section of streams
- reducing the pressure
- reducing the turbulence

Reduce noise by reducing its transmission through air by:

- using sound absorptive material on walls and ceiling in work areas
- using sound barriers and sound absorption along the transmission path
- complete enclosure of individual machines
- using baffles
- confining high-noise machines to insulated rooms

8.12 Administrative Controls

There are many operations in which the exposure of employees to noise can be controlled administratively, that are production schedules can simply be changed or jobs can be rotated so that exposure times are reduced. This includes:

- transferring employees from a job location with a high noise level to a job location with a lower one if this procedure would make the employee’s daily noise exposure acceptable;
- Administrative controls also refer to scheduling machine operating times so as to reduce the number of workers exposed to noise.
- For example, if an operation is performed during only one eight-hour day per week and the operator is overexposed on that one day, it might be possibly to reduce the operation to one-half day (four hours, two days per week). The employee then may not be overexposed.

Personal hearing protection

- Pending the application of engineering control measures, employee exposure to noise can be reduced by the mandatory use of hearing-protective devices.
- Occupational noise regulations require that whenever employees are exposed to excessive noise levels, feasible administrative or engineering controls should be used to reduce these levels.
When these control measures cannot be completely accomplished and/or while such controls are being initiated, personnel should be protected from the effects of excessive noise levels.

Such protection can, in most cases, be provided by wearing suitable hearing-protective devices.

The sound attenuation (reduction) capability of a hearing – protective device (in decibels) is the difference in the measured hearing level threshold of an observer wearing hearing protectors (test threshold) and the measured hearing threshold when the observer’s ears are uncovered (reference threshold).

Inserts or muffs are hearing-protective devices that are in common use today. The insert-type protector attenuates noise by plugging the external ear canal, while the muff-type protector encloses the auricle of the ear to provide an acoustical seal.

The effectiveness of hearing-protective devices depends on several factors that are related to the manner in which the sound energy is transmitted through or around the device. It shows a four pathway by which sound can reach the inner ear when hearing-protective devices are worn:

- seal leaks
- material leaks
- hearing-protective device vibration
- conduction through bone and tissue

### 8.13 Industrial Audiometry

Industrial audiometry is an important part of the hearing conservation programme. Briefly, the objectives to accomplish are as follows:

- Obtain a baseline audiogram that indicates an individual’s hearing ability at the time of the pre placement examination.
- Provide a record of an employee’s hearing acuity
- Check the effectiveness of noise control measures by measuring the hearing thresholds of exposed employees.
- Record significant hearing
- Comply with government regulations

An audiometer is required to help assess an individual’s hearing ability. An audiometer is an electronic instrument that converts electrical energy into sound energy in precisely variable amounts.

**Types of noise**

- Continuous broadband
- Continuous narrowband
- Impact noise
- Repetitive impact noise
- Intermittent noise

### 8.14 Specifications for Audiometers

An audiometer is a frequency-controlled, audio-signal generator. It produces pure tones at various frequencies and intensities for use in measuring hearing sensitivity. When hearing thresholds are measured, essentially it is person’s ability to hear the simplest form of sound (called pure tones) that is being measured. The audiometer was developed to provide an electronic pure tone sound stimulus similar to the tuning fork. In one respect the audiometer is superior to the tuning fork, intensities can be controlled much more accurately and therefore, the results can be more carefully quantified.
Audiogram
The audiometer is used to test hearing by finding the minimum intensity levels at which a person is able to distinguish various sounds. The results are recorded on a standard chart – the audiogram.

Frequency
Across the top of the audiogram there are several numbers (125 – 8,000 Hz). These numbers represent the frequency or pitch of sounds, expressed in Hertz (Hz). The lower numbers (125 – 250) to the left represent low – pitch sound. For example, a 250 Hz tone sounds like middle C on a piano. The tones become progressively higher numbers. A 4,000-Hz tone sounds much like a piccolo hitting a high note.

Hearing loss
A steady loss of hearing acuity occurs as we grow older. The normal young ear can hear tones within a range of 20 Hz - the lowest bass note of a piano - up to high – pitched sounds of 20,000 Hz.

Following are the sources of harmful noise:
- Industry
- Machinery
- Transportation
- Entertainment
- Community activities
- War

8.15 Bone–conduction Tests
One of the two ways that sound reaches the inner ear is by air conduction where sound travels from the outer ear through the bones of the middle ear into fluid of the inner ear. However, there is another way to introduce sound and to measure hearing. This is by bone conduction, where sound travels directly to the inner ear via the bones of the skull, a route that by – passes the outer and middle ear. Bone – conduction audiometry is rarely performed by the industrial audiometric technician, however, a basic understanding of bone – conduction tests can help when interpreting audiograms. Obviously, bone has more resistance to vibration than the air column in the outer ear canal. As a result, it takes a good deal more intensity for a listener to detect sound from the bone vibrator than from an earphone. This increase in sound output is built into the audiometer when it is manufactured and calibrated at the factory.

8.16 Types of Hearing Loss
Conductive
When tests results show that a person has depressed hearing by air conduction but normal hearing by bone conduction, the presence of a conductive hearing loss is indicated. In other words, the conductive mechanisms are impaired in some way since the normal bone conduction responses indicate that the deeper structures of the ear are intact.

Sensorineurol
If, however, the person hears just as poorly by bone conduction as by air conduction, then the hearing loss can be due to damage in the deep structures of the ear. (No matter how sound is presented to the sensorineurol mechanism; it is met by an insufficient receiver in the inner ear). This then would indicate a sensorineurol loss.

Mixed hearing loss
- A third type of hearing loss is a combination of conductive and sensorineurol. This is referred to as a mixed hearing loss. If the person has a mixed type of impairment, hearing loss will show on both types of tests.
- A conductive loss is due to simple to some impairment of sound transmission before it reaches the inner ear. A conductive impairment, then, is one that results from some interference with the function of the outer or the middle ear.
• Any blockage – usually ear wax or infection – of the outer ear that results in a loss of sound energy being conducted to the middle ear can cause a conductive hearing loss. Similarly, any impairment in the sound transmission system of the middle ear can cause a conductive hearing loss. Of course, such a loss could also be due to malfunction in both the outer and the middle ear.

• In contrast, a hearing impairment that involves only the inner ear or the auditory nerve is classified as a sensorineural impairment. (Sensory refers to the sense organ in the inner ear, neural refers to the nerve fibres). A sensorineural loss can involve either an impairment of the cochlea, the auditory nerve or both.

• It is virtually impossible to tell from an audiogram whether the damage is in the inner ear or in the auditory nerve, which is the transmission line to the brain. For this reason the loss is labeled sensorineural, because the specific area of damage cannot be determined from audiometric findings.

• Certain drugs such as quinine and streptomycin can inflict permanent injury upon the auditory nerve. Sensorineural hearing loss is a rare, but permanent, complication of mumps. Blows and skull fractures can damage ear structures. Advanced infections of the middle ear are less common since the advent of antibiotics, but are still a significant cause of hearing impairment. Tendencies to some ear defects seem to run in families. This is true of otosclerosis, which has a hereditary component.
Summary

- An ideal direct-reading instrument should be capable of sampling air in the breathing zone of the worker and should specify the concentration of the substances under investigation—either as an instantaneous concentration or as a time-weighted average, depending on what information is required.
- Work physiology means an aspect of industrial engineering that takes into account metabolic cost, measurement and prevention of work strain, and other ergonomic factors in the design of tasks and workplaces.
- An audiometer is a frequency-controlled, audio-signal generator. It produces pure tones at various frequencies and intensities for use in measuring hearing sensitivity.
- The audiometer is used to test hearing by finding the minimum intensity levels at which a person is able to distinguish various sounds.
- It is virtually impossible to tell from an audiogram whether the damage is in the inner ear or in the auditory nerve, which is the transmission line to the brain.

References


Recommended Reading

Self Assessment

1. The concentration of gases and vapours in air can be determined readily with the use of _______________ instruments.
   a. direct-reading
   b. indirect reading
   c. sampling
   d. instrumentation

2. Match the following.

<table>
<thead>
<tr>
<th>Colorimetric-type Devices</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Solid</td>
<td>a. The degree or shade of colour or the length of the colour stain is related to the vapour or gas concentration.</td>
</tr>
<tr>
<td>2. Paper tape samplers</td>
<td>b. The degree of colour indicates vapour or gas concentration.</td>
</tr>
<tr>
<td>3. Liquid</td>
<td>c. An indicator that changes colour when the reagent is consumed by a definite quantity of vapour or gas indicates the vapour or gas concentration in the sample.</td>
</tr>
<tr>
<td>4. Conductivity</td>
<td>d. The specific heat of the conductance of vapour or gas is measured to indicate the vapour or gas concentration.</td>
</tr>
</tbody>
</table>

   a. 1–a, 2–b, 3–c, 4–d
   b. 1–b, 2–a, 3–c, 4–d
   c. 1–c, 2–b, 3–a, 4–d
   d. 1–d, 2–a, 3–c, 4–b

3. _______________ means an aspect of industrial engineering that takes into account metabolic cost, measurement and prevention of work strain.
   a. Work psychology
   b. Work physiology
   c. Work sociology
   d. Work terminology

4. Which of the following statements is true?
   a. The chemical processes that transform foodstuffs into energy available for work are quite complex.
   b. The ability to move oxygen from the air to the active muscle can be improved through exercise.
   c. During eight-hour shift, the average energy required usually falls well below human peak capacity.*
   d. The heaviest work that a young, fit man can sustain for prolonged periods is about 1500 kcal/hr.

5. Heart rate and oxygen consumption have a linear and reliable relationship in the range between ____________.
   a. light and heavy work
   b. minor and major stress
   c. low and high blood pressure
   d. under and over weight

6. _______________ reacts faster to work demands and, therefore, more easily indicates quick changes in body functions due to changes in work requirements.
   a. Heart beats
   b. Blood supply
   c. Brain tissues
   d. Heart rate
7. ____________ is an overexertion phenomenon that leads to a temporary decrease in physical performance.
   a. Stress
   b. Tension
   c. Workload
   d. Fatigue

8. Which of the following statements is true?
   a. Subjective feelings of lowered motivation and deteriorated mental and physical activities may result from fatigue.
   b. It is very easy to separate mental or emotional events from physical causes of fatigue.
   c. A positive attitude toward one’s work, superiors, or place or work can just as well be a cause of clinical fatigue as well as the result of it.
   d. Subjective feelings of lowered motivation and deteriorated mental and physical activities may result from workload.

9. Advanced infections of the ____________ are less common since the advent of antibiotics, but are still a significant cause of hearing impairment.
   a. inner ear
   b. middle ear
   c. outer ear
   d. auditory nerve

10. Combination of conductive and sensorineurol called as a ________________.
    a. conductive loss
    b. permanent loss
    c. mixed hearing loss
    d. sensorineurol
Case Study I

Worksite Health Promotion in the 21st Century

Hewlett-Packard in Corvallis, Oregon, has offered a comprehensive, on-site worksite health promotion program to its employees for the past 12 years. Since its inception, Mike Waters have served as the program’s director. The program has changed dramatically during this time. Initially, it was sub-contracted to a local health club. Waters worked for the health club in relative autonomy at the Hewlett-Packard worksite. In 2002, Hewlett-Packard contracted with a national vendor, Health Fitness Corporation in Minneapolis, Minnesota, and Waters now works for them. As originally conceived, the program was within the guise of Environmental Health and Safety, with an occupational health nurse providing management oversight. Now, at the Corvallis site only, the program falls within the Training and Development group.

According to Waters, this is an important transition marking the future of worksite health promotion. “The old model was fitness based. It worked for company employees who were already active. Eighty-five percent of the employees never participated. The focus now is on providing a spectrum of services and building connections with people,” Waters reveals. “We’ve become ‘Health Coaches,’ well-rounded professionals with a broad understanding of their clients’ health interests, issues and needs. Health Coaches also understand their own limits and know when and how to refer people to those with more specific expertise. We aren’t just interested in employee fitness anymore.”

“Don’t get me wrong. We still have the fitness center and it’s a nice employee perk,” Waters affirms. “But, it’s much more about the outreach services we now provide. We believe health is more than physical. It’s personal and professional development.” Waters describes numerous employee programs he and his staff offer, including fly-fishing workshops and excursions, stress-management seminars focused on different themes, such as decluttering your home, financial wellness, marriage and relationships (with spouses and significant others welcome to participate) and time-management training.

“Next month, we are offering bird-watching walks. The idea is that someone interested in bird watching may never come to the fitness center, but will come to this. Anything to make a connection with people and help them be healthy on their own terms,” Waters adds. Worksite health promotion programs like the one Waters directs are designed to reach out to the previously unreachable. Moreover, the health fitness corporation he works for boasts a 45 percent utilization rate among company employees versus an industry average of only 25 percent.

Bottom Line is that research supports the economic value of worksite health promotion programs. These programs almost always make financial sense and directly benefit a company’s bottom line. Worksite health promotion programs are also attempting new approaches and bold experiments to get and keep employees involved, such as those offered at Hewlett-Packard’s Corvallis location. Hopefully, these innovative strategies will continue to attract a broad spectrum of company employees and, in effect, create bottom-up interest and demand for worksite health promotion programs.

Questions
1. How the transition of program is different from the old one?
   Answer
   The previous model used to focus on employees who are already active. New program focused on providing a spectrum of services and building connections with people.

2. Give an example of how the new program attracted people?
   Answer
   The new program focuses on different interest areas of people, like people interested in bird watching.
3. How the health programs are beneficial for company?

   Answer
   Health programs make financial sense and directly benefit a company’s bottom line. They also attempt new approaches and bold experiments to get and keep employees involved.
Case Study II

Unilever and Mercury Poisoning in Kodaikanal, TN

In 1984 the multinational consumer company Ponds set up a thermometer factory in Kodaikanal, Tamil Nadu, by transporting a dismantled plant from Watertown in the US. In 1997 Hindustan Lever Limited (presently known as Hindustan Unilever Limited), a subsidiary of Unilever, the Anglo-Dutch consumer-care firm acquired the thermometer plant as part of Unilever’s global acquisition of Ponds. In 2001 Greenpeace and Palani Hills Conservation Council (PHCC) uncovered and brought into the public domain the severity of HUL’s acts of toxic dumping.

Over the course of its functioning, the factory in Kodaikanal exposed its workers to the hazardous substance mercury and also released tons of mercury waste into its surroundings. Mercury is best known for its use in thermometers but it has nearly 3000 industrial uses such as in paints and industrial instruments. Mercury is a neurotoxin and it can damage the brain, heart, kidney, and liver. Workers of the thermometer factory were not warned of the hazardous nature of mercury, nor were they given any protective gear. At least 19 workers from the factory have died till date. Faced with the inability to work and massive medical expenses, several workers and their families are confronting destitution. The company refuses to come to the aid of those poisoned by it, and is delaying clean up to international standards.

On 25 February 2008, the Office Bearers of All India Council of Unilever Unions on being informed about the present pathetic condition of the Ex-workers and their families of Kodaikanal factory discussed this issue and unanimously decided to support the struggle of Kodaikanal workers & their families and passed a resolution to “work jointly with the ex-workers of Kodaikanal for getting them justice and compensation to the mercury affected workers & their families from the Hindustan Unilever Management.”

Questions
1. How it is hazardous to work in mercury plant?
2. What are the uses of mercury?
3. How the office bearers of All India Council of Unilever Unions provided their support?
Case Study III

Lowell Center for Sustainable Production’s Lessons Learned: Solutions for Workplace Safety and Health

Every day in the United States, 14 workers die on the job and millions of workers are seriously injured or sickened by doing their work. The harms to workers, the costs to our healthcare system, and the damages to communities are immense.

Yet many of these injuries and deaths could have been prevented by applying the lessons learned from our country’s history of workplace health and safety. It is a history rich in powerful examples of regulations failing to protect workers as well as policies and practices that enable workers to be healthy and safe. These lessons can be used to create far more effective approaches that not only protect workers but also reduce the harms to society.

Going to work should not be a choice between feeding your family and protecting your health and safety. To make these lessons clear and useful, the Lowell Center for Sustainable Production has produced Lessons Learned: Solutions for Workplace Safety and Health.

Effective practical solutions

Lessons learned identifies some high-priority strategies for making workplaces safer. While improved regulations and enforcement are clearly needed, there are many other opportunities to improve worker health and safety.

Comprehensive workplace injury and illness prevention programs that tap worker and employer knowledge, expanded safety and health protections for immigrant workers, strengthened expertise in occupational and environmental health, and proven practices to systematically identify and control workplace hazards all play a role.

A crucial conclusion of this research is that work-related injury and illnesses could be prevented if chemicals, production processes, and technologies were designed with worker health in mind. “Prevention through Design” initiatives are now being used to design buildings that eliminate hazards and make jobs, products, and materials inherently safer.

With the current need to get people back to work and green the economy, stimulating innovation that designs out hazards holds great promise for breaking free of the false dichotomy of safety versus profit - it doesn’t have to be a trade-off.

Questions

1. How the lessons learnt can be used in safety of workers?
2. What should be kept in mind while designing the chemicals, production process and technologies?
3. Suggest one solution for worker safety.
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Self Assessment Answers

Chapter I
1. a
2. b
3. c
4. d
5. a
6. c
7. b
8. d
9. a
10. c

Chapter II
1. a
2. b
3. b
4. d
5. a
6. c
7. d
8. a
9. b
10. b

Chapter III
1. a
2. b
3. a
4. c
5. c
6. d
7. a
8. a
9. d
10. a

Chapter IV
1. a
2. c
3. d
4. b
5. a
6. b
7. d
8. b
9. a
10. d
Chapter V
1. a
2. c
3. b
4. a
5. c
6. a
7. c
8. b
9. d
10. a

Chapter VI
1. a
2. b
3. c
4. b
5. d
6. a
7. a
8. a
9. c
10. b

Chapter VII
1. a
2. b
3. a
4. c
5. d
6. d
7. c
8. a
9. d
10. c

Chapter VIII
1. a
2. a
3. b
4. c
5. a
6. d
7. d
8. a
9. b
10. c